MINISTRY OF AGRICULTURE, EGYPT.

Technical and Scientific Service.

Bulletin No. 44.

The Propagation and Cultivation of Citrus Trees in Egypt

By Thos. W. BROWN, F.L.S.

(Recommended for publication by the Publications Committee of the Ministry of Agriculture, which is not, as a body, responsible for the opinions expressed herein.)

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PREFACE.

Munir Eff. Boutros, Sub-Inspector, Hussein Eff. El Gayar, Technical Assistant, and Sheikh Ahmed El Bakry have read the following notes in manuscript and have suggested certain modifications. Munir Eff. Boutros is also responsible for the translation into Arabic. Tewfik Eff. Fahmy, Assistant Mycologist, has made certain suggestions *re* fungous diseases. My thanks are, therefore, due to the above officials for the valuable assistance thus rendered.

Thos. W. Brown.

The Propagation and Cultivation of Citrus Trees in Egypt.

Introductory.

During the year 1919, Egypt imported fresh fruit to the value of L.E. 563,999. Included in the above is a quantity of nearly nineteen million kilos. of oranges and lemons valued at a sum of L.E. 237,083. An examination of the conditions under which this branch of our import trade is carried on leads to the conclusion that to a great extent it represents a loss to the country.

Leaving aside the possibility of the establishment of an export trade, we should consider whether we can produce at least what we require for our own needs.

We have both suitable soil and climate. Oranges grow well in any part of the country from the Mediterranean to Aswân. They can be grown on land which is too poor and sandy for the cultivation of cotton or maize, and on good land they yield profits equal to those derived from the most valuable crops now grown. What then are the reasons why we must depend upon other countries for the supply of such a large part of the oranges and mandarines which we now consume ? If we try to answer this question, we find that the cause of this state of affairs is the fact that very little attention has been given to the cultivation of fruit by agriculturists in Egypt.

The care of plantations is left in the hands of workmen who have no knowledge of the treatment of trees, nor of the measures to be taken to prevent disease.

It should always be remembered that the pests which trouble us here are being controlled in other countries.

If cultivators will devote as much intelligence and energy to the study of fruit cultivation as they have given to the study of other agricultural crops, it will soon be found that it is possible to grow fruit, and especially citrus fruit, as easily, if not better, than is done elsewhere.

This pamphlet is published in the hope that it may be of some help to those who are giving their attention to this important question.

Propagation.

People who make fruit plantations, almost invariably purchase the young trees from other cultivators who propagate a certain number of plants for sale each year.

The commercial nurseries of Europe and other countries equipped with highly trained workmen and modern arrangements for the packing and despatch of plants are almost unknown in Egypt. Cultivators who propagate trees for sale in this country usually do it on a small scale side by side with some other form of cultivation. The work has not yet developed into a specialized industry, and the methods employed in digging and transporting plants are for the most part very crude and defective. For cultivators who make mixed gardens of limited area, it is of course impracticable to propagate the different kinds of trees required, but those who make large or moderately large plantations of one kind of fruit tree will always find it advantageous to propagate the plants on the spot. It is seldom advisable for the ordinary proprietor to plant more than five feddâns of permanent orchard in one year, unless he has the assistance of expert workmen other than the fellaheen gardeners who are usually employed in the provinces. The season of planting is short in Egypt, and those who, without any special organization or help, attempt to do too much in one year, usually make mistakes which cannot be rectified afterwards. The most practical manner of creating a large plantation of citrus trees is to spread the work over three or more years, the gardener propagating sufficient trees to plant five feddâns or less each year. The fact of the young plants being near the site of the permanent plantation facilitates the work of transferring them to their new home. This can be done at the moment when water is available and other circumstances are most favourable, without making intricate arrangements, which seldom work smoothly, for the plants to arrive by rail or otherwise at the desired time. In the case of plants which are removed with a ball of earth attached to the roots, there is no question, when the trees are propagated at home, of reducing the cost of transport by reducing the size of the ball beyond the limit of safety; and injuries are avoided which are invariably caused to such plants by long transport, especially where camels have to be employed. A gardener who is capable of properly cultivating trees after they are planted in the field, may reasonably be supposed to be sufficiently intelligent to propagate them, and employers should insist that the number of young plants required for future developments be propagated yearly.

Citrus trees are propagated by means of cuttings, layers, seeds, and grafting.

Cuttings.

Cuttings are usually employed for the multiplication of the citron (Ar. *Trong*) and for the propagation of the Egyptian Sweet lemon also. The cuttings are made of young branches which are cut into pieces about twenty centimetres long. They are planted in the month of February, care being taken that no more than one bud is allowed to remain above the surface of the ground. The young plants of citron are usually grafted with oranges or mandarines in the following September.

Layers.

Citrus trees are sometimes propagated by means of layers. An incision is made in a branch which is about as thick as the finger, after which the branch is bent to the ground and covered with earth at the point of the incision. If the branch cannot be bent to the ground, a receptacle containing soil is placed around it at the point where the cut has been made. This method of propagation is clumsy, slow, and otherwise unsatisfactory.

Seed.

Seed is always employed as a means of propagating the Bitter orange and the Common lime. Other kinds of citrus trees are also raised from seed, when they are used as stocks. Some cultivators prefer seedling trees of oranges, even for the production of fruit, on account of the fact that the seedling trees often bear larger fruit than those which are grafted. Seedling trees are, however, open to the following objections :—

(1) They attain a height and size which make it very difficult to collect the fruit without bruising.

(2) Their great height causes them to be injured by wind to a greater extent than grafted trees of comparatively low growth.

(3) It is very difficult to fumigate or otherwise treat high trees when they are attacked by insect or fungous pests.

(4) Seedling trees are more thorny than those which are grafted. This fact further increases the difficulty of collecting the crop, and the presence of the thorns leads to a certain number of the fruits being pierced and injured by the movements of the branches on windy days.

(5) Trees grown from seed do not commence bearing until they are six to seven years old, so that the owner must wait longer for his returns than in the case where he plants grafted trees.

(6) Although the seedling plants always produce fruit of more or less good quality, they invariably differ one from the other in their productiveness and in the characters of the fruit. For Egypt to compete in foreign markets with other orange-producing countries, it is essential for our fruit to be uniform in quality. This condition does not exist where plantations are composed of seedling trees.

(7) The presence of thorns on the trees increases the difficulty of fumigation, owing to the fact of the tents being torn in the operation.

(8) The last argument against the use of seedling trees is one which appeals to every cultivator, no matter whether he grows oranges for sale or for his own use. It is that many kinds of citrus trees, when grown on their own roots, are subject to "gumming" both on the branches and at the base of the stem. Certain species, such as the Bitter orange, are, however, more or less immune to the disease and trees of Sweet oranges, etc., grown upon stocks of Bitter orange are seldom attacked, whereas entire gardens of Sweet orange trees growing upon their own roots have been, and are being, destroyed by the disease (Fig. 2). In all countries where citriculture is practised systematically and scientifically, seedling trees have, for the above reasons, given place to those which are grafted.

Even in the case of *beledi* limes, which are seldom attacked by the above-mentioned disease, it is better to use grafted plants. In almost every plantation of limes, we find one or more trees which have exceptionally good qualities. If the whole plantation is composed of such trees, the revenues are of course very high. Such a plantation can be created only by the use of grafted plants which have been propagated from selected trees.

Preparation of Seed.

Whether we make our plantation of seedling or of grafted trees, it is necessary to know how to raise them from seed, in order to obtain young plants upon which to graft.

In order to achieve the greatest success, it is essential for the seed to be perfectly fresh at the time of sowing. It is not always easy to obtain fruits from which to take seed when it is required. In the case of the Bitter orange, for example, the fruit is usually both scarce and expensive in the month of March. If a sufficient quantity is cultivated on the estate, it may, of course, be left on the trees until the seed is required, but where it is necessary to purchase the fruit, it must be bought before the weather is sufficiently warm for the sowing of the seed. In such a case, it is usual to follow one of two courses.

The first is to extract the seed from the fruit and to store it in light soil until the time of sowing arrives.

The alternative course is to store the fruit in clean sand and to extract the seed when it is required.

The most practical method of taking the seed out of the fruit is to cut the latter into halves and place the seed and pulp in sieves. The pulp is washed away with water, after which the seeds are spread in the shade until they are sufficiently dry to be handled. They are then sown without further delay, or stored in sandy soil as explained above. In Lower and Middle Egypt, the most suitable time for sowing seed of all kinds of citrus trees is the month of March. In Upper Egypt, it may be sown earlier. Seed of lime trees is, however, often sown in September, owing to the fact that ripe fruit is then more plentiful than at other seasons (Fig. 3).

Preparation of Seed-beds and Method of Sowing.

The land where the seed is to be sown is trenched. It is then arranged in beds forty to fifty centimetres wide. A shallow drill is made along each side of the bed, and the seed sown in a continuous line along the drill. It is then covered, to a depth of about five centimetres, with sweet sand or sandy soil. The use of pure sand gives the best results. The practice of making wide beds and sowing five or six lines of seed in each bed is not to be recommended. In the system described above, the lines of seed are at least forty centimetres apart and the beds are separated by ridges which are also forty centimetres wide. There is thus ample space in which to manure and till the ground throughout the summer. We should avoid making the beds too long. In long beds the young plants at the end next to the canal inevitably receive too much water. Therefore, the beds should not be more than seven metres long. Needless to say, the ground must not be allowed to become dry after the seed is sown. As a precaution against this, many cultivators shade the beds lightly with cotton-sticks, etc., until the young plants are established. Others cover the beds with chopped straw (Ar. *Tibn*).

Sowing in Pans and Boxes.

In cases where the land is heavy and where sand is not available to lighten the soil, it is advisable to sow the seed in pans or boxes and to raise the seedlings in pots. A small quantity of Nile soil and decayed manure suffices for the cultivation of considerable numbers of young plants in pots until they are twenty to thirty centimetres high. When they have arrived at this stage, they are able, with the help of good tillage, to grow in the open ground under

conditions which would be fatal to germination and to the growth of the plants at an earlier stage.

Care of Seedlings.

During the stages of germination and early growth in beds, the work of weeding must be done with the greatest care. At first only the leaf growth of the weeds is taken off above ground, no attempt being made to pull out the roots. When the rows of seedlings are clearly visible, the beds are weeded by means of the trowel or *shukrut*. The hoe is employed as soon as the seedlings have two to three leaves each, but even then it must be used with care in order to avoid disturbing the plants. When they have passed the seedling stage, the ground should be hoed as frequently as possible. It should also be manured once or twice during the summer with farmyard manure or a nitrogenous artificial manure.

Transplanting Seedlings.

Seed of Bitter orange which is sown in March will, on good land and with good treatment, produce plants sufficiently large to be planted in the month of September of the same year. On poor land, on the other hand, they may not be ready for transplanting until March of the second year. When dealing with seedlings which are not more than twenty centimetres high, it is better to transplant in September than in spring, but in the case of larger seedlings the work should be done towards the end of February. Seedlings of Bitter orange or lime which are used as "stocks" must be transplanted from the seed-bed to the nursery before being grafted. Seedlings of Sweet orange, lime, etc., which are not required for grafting are often allowed to remain in the seed-bed until they are sufficiently large to be planted in the orchard. This practice, however, leads to the production of attenuated, badly-rooted plants which are "dear at any price" to the planter. No matter for what purpose the seedlings are required, they should be grown in nursery rows for at least a year after they have been taken from the seed-bed, and before they are transferred to their permanent places in the orchard.

Planting Seedlings in Beds and on Ridges.

In the nursery, the seedlings are planted either on ridges or in flat beds. Whenever the land is good, the practice of planting on ridges is the best, but where the land is such that the ridge becomes covered with an efflorescence of salt, it is better to plant the young trees in beds. In the latter case, every precaution must be taken

to make the beds level, otherwise many trees which are situated in depressions receive too much water and die. No matter what methods are employed, the task of raising young trees on land which is not free from salt is a difficult one, even though adult trees grow moderately well on the same land. Under such circumstances, it is better to buy than to propagate the trees required.

Methods of Moving Seedlings from Seed-bed.

When the young plants are ready for removal to the nursery row, the seed-beds are heavily flooded once or twice, in order to wet the land as deeply as possible.

Whilst the land is still wet, the soil is removed from each side of the row of seedlings to a sufficient depth to allow them to be lifted easily in clumps with the wet soil adhering to the roots. This work is most effectively carried out by means of a hoe with a long narrow blade (Fig. 4).

It cannot be done properly with an ordinary *fass*. The long-headed hoe spoken of is necessarily in many phases of tree-propagation, and it should form part of the equipment of every nursery.

Methods of Planting Seedlings on Ridges.

As stated above, moderately small seedlings may be planted early in September, and at the end of February seedlings of any size may be transplanted. Before removing the young plants from the seed-beds, the land to receive them is well ploughed and manured. If the seedlings are large, the following course is adopted :—

Furrows are first made with the plough seventy centimetres apart, and along the furrows trenches are then made with the narrow hoe already described. The trees are then planted in the trenches, so that the upper part of the root is slightly above the surface of the ground. Two men are employed to plant the trees : one to hold them in position, and another to draw the soil around the roots with his hands. Other men follow the planters and "earth up" the trees on each side with hoes and thus cover up any roots which have been left exposed to the air. When the work is finished, the plants are standing in the middle of the ridge, and the irrigation water flows between the ridges. It is most important that the trees should be watered immediately they are planted. The fellaheen gardeners usually finish the planting first and water afterwards. Meanwhile the lack of moisture is killing the trees which were first planted. The water should follow the workmen along the furrows as the work proceeds.

In order to achieve the best results, the work must be well orga-

nized, so that the least possible time elapses between the removal of the trees from the seed-bed and the watering of the land where they are afterwards planted. It is also important for the welfare of the plants that the length of the furrows should not exceed seven to eight metres from the inlet of the water to the end of the flow.

Young seedlings which are not more than fifteen to twenty centimetres high may be planted in the same way as cabbage or other vegetable seedlings on ridges. The furrows are filled with water and the seedlings planted in the mud by hand. This is the cheapest and most practical way of planting seedlings, as the ridges are made with the plough and very little hand-labour is required.

Planting Seedlings in Beds.

Where seedlings are to be planted in beds, a hole is made for each plant after the beds have been prepared.

As soon as the seedlings are planted in the holes, the beds are levelled and watered. The workmen commence planting at one end of the bed, another workman levels the soil immediately behind those who are planting, and the water flows over the bed as soon as it is levelled.

The interval between the time of planting and that of watering is thus reduced to a minimum and, consequently, the check to the plants is not great. Needless to say, planting in beds requires more labour and is, therefore, more expensive than planting on ridges.

Care of Young Plants in Nursery.

The most important point of cultivation in the nursery is that of weeding and tillage.

Wherever the size of the nursery is sufficiently large to allow the plough to be used, it should be employed in preference to the hoe. It breaks up the land much more effectively than can be done by means of the hoe. To enable the plough to be used, it is necessary to have a space of not less than seventy centimetres between the ridges, and between the plants in the ridges. Care must also be taken to place the plants in straight rows in both directions. Where this is done, the land can be ploughed both lengthwise and crosswise and hand-cultivation greatly economized (Figs. 5 and 6). Good tillage ensures the steady growth of the plants, but if it is seen that they are not making proper progress, a dressing of nitrate of soda should be given every two months during the summer. When the seedlings are first planted they require frequent watering. The intervals between the waterings must the regulated according to be size of the plants and the kind of land upon which they are growing.

Seedlings which are transplanted in September or February may be ready for budding in the following September, provided the land is good and that it is well cultivated during the summer. If, however, the stocks have not attained a sufficiently strong stem to be budded at the proper height, it is well to postpone the budding until spring. Not only must the stocks be sufficiently large, but they must also be healthy plants. Budding upon plants of stunted growth is never attended by a large measure of success.

It is therefore highly important that the young plants should receive the best possible treatment after they are transferred from the seed-bed to the nursery.

Grafting.

Grafting is the process of taking a branch or a bud from one tree and making it grow on another tree. The bud or branch thus transferred grows and produces leaves and fruit of its own kind, whilst it draws its nourishment from the roots of the tree upon which it is grafted. The tree upon which another is grafted is called the "stock." The part of the branch which is grafted upon the stock is called the "scion," and grafting by means of buds is known as "budding." Grafted trees produce leaves, etc., similar to those of the tree from which the bud or branch was taken. The process, therefore, constitutes a valuable means of multiplying individual trees which have desirable qualities. In many cases, such trees cannot be reproduced by any other means. In every plantation may be found a few trees which are notably more prolific than the others. It is, of course, unneccessary to point out that a plantation which is composed entirely of highly prolific trees is vastly more profitable than one which contains many "drone" trees.

Choice of Bud-wood.

Grafting enables us to produce trees of a uniformly high-class character, but to do this it is necessary to select the trees from which to take the buds for grafting. This is entirely neglected in Egypt, and the tendency of the present-day practice is to multiply the number of "drone" trees in much greater proportion than in the case of trees which bear freely. The buds are taken for the greater part from trees of strong vegetative growth, because they are easily found on such trees. It is much more difficult to find buds on plants which bear heavy crops, and as the curtailment of work is of first importance in the minds of the fellaheen gardeners, the best trees are propagated to a much less extent than those which produce many shoots and few fruits.

Buds are most easily taken from shoots which are round and not angular. Expert workmen are able to take buds from angular shoots, but the fellaheen gardeners seldom achieve any great measure of success in doing it. The shoots must also be free of thorns. This sometimes presents a difficulty in the propagation of a selected tree which has been grown direct from seed. The difficulty may, however, be easily overcome by removing the thorns with the finger and thumb, as they appear on the young shoots. The thorns must be taken away when they are quite small and tender, for which reason the tree must be visited at frequent intervals when the shoots are growing. If this is done, the buds develop normally in the axils of the leaves and may be used later for the propagation of the tree.

Another point to be observed in gathering bud-wood is the freedom, or otherwise, of the trees from injurious insects and fungi, so that the introduction of these pests into young plantations may not be effected by means of the shoots used for propagation.

Bud-wood should be Fresh.

In budding, the greatest measure of success is attained by using the buds immediately after the shoots have been cut from the parent trees. Buds and shoots may be employed several days, and even weeks, after the shoots have been cut, provided that they are suitably packed. This is a cheap way of importing new varieties from other countries, but for routine work in the nursery the parent trees should be near at hand, so that the buds may be used in a perfectly fresh condition. Bud-wood which has travelled a long distance by post may not be sufficiently fresh for the buds to be removed from the shoots. In such cases, we have attained considerable success by employing the system known as side-grafting.

Side-grafting.

In side-grafting, the base of the scion is cut in a sloping direction on one side. A T-shaped incision is then made in the bark of the stock, and the scion slipped underneath the bark, as shown in (Figure 7 A.). The operation may also be carried out by cutting into the wood of the stem in various ways, and making the base of the scion to fit.

This form of grafting is sometimes used when the scions are too angular for the buds to be easily removed, or, as already stated, when the scions are not quite fresh. The average cultivator, however, seldom has need of it, and the expert gardener who may employ the system usually has access to literature specially devoted to the subject of grafting.

It is therefore unnecessary to describe the system of side-grafting more fully than we have already done ; in fact, the only method of grafting which is generally used in the propagation of citrus trees is that of budding.

Budding.

In budding, the scion consists only of a bud with a piece of bark attached. The operation must be done when the stocks and the plants which supply the buds are growing and full of sap, so that the bark can be easily detached from the wood without injury. In the method of budding most commonly practised, the bud is removed from the shoot with a piece of bark of the shape shown in the sketch (Fig. 7 B). A T-shaped incision is then made in the stem of the stock and the bark raised on both sides of the cut, so that the bud is easily inserted underneath. Raffia fibre is bound around the stem to keep everything in place, and the operation is thus finished. A certain amount of skill, which can only be acquired by practice, is needed to carry out the work well. The bark bearing the bud must be neatly removed with clean-cut edges from the shoot. The bark of the stock must also be raised without injury to the tissues, and the bud inserted before it has time to become dry by exposure to the air. This method of budding is known as " shield budding." It is of course subject to numerous modifications and developments, and almost every expert propagator differs in some detail from his neighbour in the way in which he carries out his work. Thus the incision of the bark may be made in the form of a Latin cross instead of the T-shape which we have shown, or again the T may be inverted thus : ⊥. The shape of the bud-scion must of course vary according to the form of the incision, being made to taper at both ends or cut horizontally below the bud, as the case may be. A few growers regard it as being absolutely necessary to leave a thin layer of wood underneath the bud, but the majority of cultivators are more successful when this is not done. A man who wishes to be an expert in grafting must study the peculiarities of each kind of plant. The intelligent observer soon finds that in budding citrus trees the greatest proportion of successes are usually among the lemons, and the fewest among the mandarines. He also finds that there is usually a greater number of failures among the buds of Navel oranges than among those of other varieties of oranges. He will, therefore, be careful to choose the coolest days for the budding of the mandarines and Navel oranges, leaving other kinds of oranges, together with the lemons, to be done during less propitious weather. The best tying material is the raffia fibre already mentioned. Banana fibre, however, is most frequently used, owing to the fact that it is

always available and can usually be obtained gratis in any part of the country.

Grafting can only be learnt by Practice.

It will be seen from what we have said that the art of grafting is not such as can be learnt from books. Workmen should commence by preparing scions and buds of willows, poplars, or similar trees of little value. They must then practise binding and securing the ties. This must be done on the stem of the plant at a point near the ground, where the gardener must work in the posture which he assumes when actually grafting. Where there is more than one man engaged in budding, it is well for them to work in pairs. One prepares the buds and inserts them on the stock, whilst the second does the tying.

Budding-knives.

Special knives are sold for the purpose of budding. These are furnished with a flat attachment of bone for raising the bark of the stock without injury. It is very necessary to keep the edge of the knife absolutely smooth and sharp, and for this reason the workmen should have a hone always at hand.

Seasons for Budding.

The first budding of the year is done as soon as growth commences in the stocks and in the trees from which the buds are taken. Frequent tests are made in the latter half of February and early in March, to ascertain when the sap has risen sufficiently to enable the bark to be easily separated from the wood. Care is taken to keep the land moist, in order to encourage the flow of sap as much as possible early in the season. A higher percentage of the buds succeed in spring than is the case later in the year. The number of failures at this season is often not more than ten or twenty per cent, whereas seventy per cent of the buds may die when the weather is hot. In spring and summer, budding is continued until the end of May. During June and July, nothing is done, except the re-budding of occasional plants which have previously been missed. The work is recommenced in August and continued until the middle of November in Lower and Middle Egypt, or even later in Upper Egypt. For reasons already given, the mandarines and Navel oranges are budded early in spring and in autumn when conditions are most favourable. In Upper Egypt, we have been most successful in the month of October with all varieties of citrus trees.

Removing the Ties and cutting back the Stocks.

Three weeks after the time of budding, it is possible to see whether the bud is alive or dead. When the bud is inserted, the base of the leaf-stalk is left on the bark which bears the bud. If this piece of leaf-stalk dies naturally and falls off, it is a good indication that the bud-scion is uniting with the stock. If, on the other hand, the leaf-stalk withers and adheres firmly to the bud, it is probable that the latter is dying. In any case, at the end of the period mentioned above, it is usually possible to say definitely whether the bud has "taken" or not. When it is seen that a union has been formed, the tying material is removed. This should not be left longer than is necessary, as it prevents the natural increase in thickness of the stock and may thereby kill the bud.

In the case of plants which are budded in spring and early summer, the stock is cut off at a distance of fifteen centimetres above the bud, as soon as the raffia is taken away.

Plants which are budded in August and later are, however, not cut back until February of the following year.

Cutting off the head of the stock encourages the grafted buds to commence growth. Although it is desirable for this to take place as rapidly as possible in spring, it is better for the buds which are grafted in autumn to remain dormant throughout the winter.

Those which commence growth late in the year produce shoots which cannot mature before winter arrives, and in consequence they either die altogether or are greatly weakened if severe weather comes in January.

Plants which are budded in autumn are therefore cut back in February.

The part of the stock which is left above the bud serves as a stake for the support of the young graft when growth commences. As soon as the delicate young shoot is three or four inches long, it is tied loosely to this support, with the double object of preventing the shoot being broken, and of training it in an upright direction whilst still young and tender. After the stock is beheaded, all the shoots which are produced below the graft must be removed. A few shoots are allowed to grow on the piece of stem above the bud, but their increase in size is restricted to what is necessary to keep the circulation of sap going until this can be done by the graft itself.

When the shoot arising from the grafted bud is sufficiently large to perform the above function and to support itself, the stem of the stock is cut off quite close to its union with the graft. After this is done, all growths on the stock are removed as soon as they appear. If this does not receive constant attention, shoots arise on the stock and prevent any increase in size on the part of the graft.

Height of Bud above Ground.

The height above the ground at which the bud is inserted on the stem of the stock is a matter of some importance, especially if the stock used is of a kind which is not subject to collar-rot or other forms of gumming.

The point of union of a graft on the bitter orange stock, for example, should always be sufficiently high to prevent it being covered with soil at any time in the life of the tree. On the other hand, the practice which is sometimes followed of budding at a height of sixty centimetres and even more, is open to several objections. Not only are plants budded at such a height expensive to produce, but their growth is always slow, at least in the first years of their existence.

Trees which are budded at a height of twenty to thirty centimetres above the ground have given good results in all respects (Fig. 1).

Site of Nursery.

As we have already stated, the land upon which citrus plants are propagated must be sweet and well drained. Heavy clay land is not good, because young plants grow slowly on such land. Land which is composed of moderately heavy loam is the most suitable. On light *gezîra* land, it is difficult to transplant trees with a ball of earth, as the sandy soil falls away, even with the most careful packing. The trees can be transplanted with perfect success without any earth on the roots, but the operation requires more care than is given to it by the average fellah. The different methods of transplanting will be discussed more fully later. Meanwhile it is sufficient to state, that, where adequate supervision is given to the removal and re-planting of trees with naked roots, there is no serious objection to the nursery being situated on light land. The commercial nurseryman cannot, however, follow his trees to their destination, nor guarantee their proper treatment at the hands of the purchaser. He will therefore choose a site for his nursery where the soil is sufficiently compact to enable him to dispatch his plants with a ball of earth if necessary.

It is also important that the nursery be sheltered from wind.

If the site chosen is exposed, no time should be lost in providing the necessary shelter by surrounding the site with Casuarina trees, at least on those sides from which the wind blows at different seasons.

We have already spoken of the injury which may be done to young shoots in winter.

In spring, the effect of the hot khamsin wind is sometimes even more disastrous than the cold winds of January.

If the nursery is large or in a very exposed position, it may not be sufficient to plant Casuarina on the outside boundaries only.

Shelter lines of trees may be necessary in the interior also. A nursery which is isolated from other gardens is more easy to keep free of insect pests than is the case with one in close proximity to neglected plantations or to ornamental gardens. It is well to keep this in remembrance if we have a choice of sites at the outset. In any case we should always refrain from planting near the nursery such trees as *Eugenia Jambolana* or other host-plants of citrus-tree pests.

Some cultivators advocate the planting of the stocks in the field and budding them afterwards. This course, however, is disadvantageous in several respects and should only be followed in special cases.

Commercial Nurseries.

Certain varieties of oranges, etc., can be distinguished from other varieties by the size of the leaves, manner of growth and other characteristics. This, however, is not true in all cases. Especially in commercial nurseries, it is important that each variety be kept apart and properly labelled.

Purchasers may thus be reasonably sure of obtaining the kinds which they require, and the seller thereby acquires a reputation which enables him to increase his business and profits in the future.

In budding, each row or number of rows should be confined to one variety. A plan may be made showing the distribution of the different kinds, which can thus be easily located, even if the labels are lost or mixed. On the other hand, it is often desirable to bud Italian or other lemons late in the season on stocks which have been previously budded with mandarines or oranges. This leads to the mixing of mandarines and lemons for example, but where the distinction between the two kinds is very marked, as in the example cited, they are easily separated at the time of transplanting, and the fact of the two kinds growing together is therefore not open to any serious objection.

The number of plants which a man is able to bud in a day of ten hours varies between 100 and 150. With the great majority of workmen it usually approaches the lowest figure most closely, and if they have no assistants to gather the bud-wood, their day's work will seldom attain even an average of 100 buds per man.

At the end of the planting season, there is invariably a number of small or otherwise unsaleable plants remaining in the nursery. These should be collected and planted on fresh ground which has previously been well manured. At the same time they must be severely cut back and defoliated. This assists the plants to start the new season's growth free of any scale insect which may have started its attack on the leaves of the previous year.

Supply of Bud-wood.

To every nursery of any importance must be attached a plantation of permanent trees for the supply of buds. If the propagator depends upon any chance supply from orange groves in the vicinity, he cannot attain the most satisfactory results in his nursery. Where he owns his own plantation he has an opportunity of becoming acquainted with each tree and of verifying its identity and its quality. The plantation which is kept for the purpose of supplying bud-wood does not produce large quantities of fruit. The quality of the fruit borne by each tree can, however, be ascertained, and, if the plantation is sufficiently large, the yield of each tree can be studied for a few years, whilst taking the buds from other trees.

"Stocks."

The stocks which are most commonly used in the propagation of citrus trees are the Bitter orange, the Sweet orange, the lemon, the lime, the pomelo, the Sweet lemon of Egypt, the citron and the Trifoliate orange.

The Bitter Orange as a Stock.

This is easily raised from seed and it is not liable to the attacks of collar-rot. Citrus trees which are grown upon the Bitter orange stock are comparatively dwarf and of moderately slow growth. The fruit is somewhat smaller than that of trees which are grafted upon Sweet orange and lemon stock, but, although slightly reduced in size, it is nevertheless of good quality. The Bitter orange as a stock is supposed to have the property of retarding the ripening of the fruit and of accentuating the natural tendency of the trees to bear well in alternate years only. Notwithstanding these defects of minor importance, it is, as far as we know at present, the safest stock to use for the propagation of most of the different kinds of citrus trees cultivated in Egypt. All varieties of citrus trees do not, of course, grow equally well on the same stock, and it has been found that the Sweet lemon of Egypt and some of the seedless lemons cannot be grown with success on the Bitter orange. It is sometimes stated that the Bitter orange is an unsuitable stock upon which to grow the Navel orange, but our experience with these in Egypt is not sufficiently long to enable us to confirm this statement, although trees of this variety on the Bitter orange are growing more strongly than trees of the Egyptian Sweet orange on the same stock. We cannot say, however, whether trees on some other stock will fruit more freely than those on the Bitter orange, or whether the latter will yield more freely as they increase in age.

The Sweet Orange as a Stock.

Trees which are grafted on stocks of Sweet orange grow more strongly than those which are grafted on the Bitter orange, but, on account of the fact that the Sweet orange stock is subject to the attacks of "mal-di-goma," its use is not recommended.

Lemon Stocks.

Lemon trees of different kinds are used as stocks in various parts of the world. The best known of these is the Rough lemon of Florida, which is closely allied to the common Italian lemon. Trees which are grafted upon this stock grow quickly and attain a large size. The fruit is also large. It is said that during the first few years of yielding, the fruits of orange trees grown upon lemon stocks contain more acid than those of trees which are grafted upon the Bitter orange. This difference, however, evidently disappears in older trees. There is some doubt as to the immunity of the Rough lemon to the attacks of "mal-di-goma," and it has not yet been tried on a sufficiently large scale in Egypt, to enable us to state whether it is a safe stock to use in this country. It is, however, worthy of trial.

The rough lemon of Egypt has been tried as a stock in Egypt for oranges, mandarines, and grape fruits, but the trees were found to "gum" very badly.

The Common Lime as a Stock.

This a a tree which deserves extended trials as a stock in Egypt, especially for lemons which do not grow well upon the Bitter orange. The fruit of orange and mandarine trees which are grafted upon lime stocks is said to be of excellent quality, and the tree is almost immune to the attacks of "mal-di-goma."

The lime is being used experimentally as a stock in the Government gardens. It is found that the work of budding the young plants is somewhat more difficult than it is in the case of the Bitter orange.

The Sweet Lemon of Egypt as a Stock.

This tree is largely used at Jaffa, together with the Bitter orange, as a stock upon which to graft the Shamooti orange. The Sweet lemon is preferred to the Bitter orange on light soils. The trees are said to be more precocious but of shorter life than those of the Bitter orange. Some cultivators also consider that they bear a yearly crop more regularly, without any marked alternation of good and bad seasons.

The Shaddock as a Stock.

Seedling trees of the shaddock are supposed to be as resistant as the Bitter orange to the "mal-di-gomma" disease. The species is said to be unrivalled as a stock on dry land. Unfortunately, the variety which is usually cultivated in Egypt is extremely subject to the attacks of the scale insect, *Aspidiotus aurantii*, even one-year-old plants in the nursery frequently have their stems infested with the insect. This defect naturally makes it difficult to raise healthy young stock upon which to bud. Other varieties, which have not up to the present been attacked by the insect, are now being distributed as fruit plants by the Ministry of Agriculture. They are also being tried as stocks for other citrus trees. These varieties are evidently of hybrid origin, because the seedlings vary greatly in leafage. It is therefore necessary to select severely, in order to obtain uniform stocks of the pomelo type. Even if these are found to be superior to the Bitter orange, it will not be possible to employ them on a large scale until the quantity of seed now available has been largely increased.

The Trifoliate Orange.

This has for many centuries been employed as a stock for all sorts of citrus trees in China and Japan, and is now used in many other countries also: but trials in Egypt have demonstrated the fact that it is entirely unsuited to the conditions of this country.

Citron Stock.

The stock which is most largely used in Egypt for the propagation of orange and mandarine trees is a variety of citron known as "Trong Baladi." The chief reason for its extended use is the fact that the trees are most easily and rapidly propagated by means of this stock. The citron is grown from cuttings which are planted in February, the young plants being budded with oranges in the following September, without any transplanting being done. Owing to the sappy nature of the stock, grafting is very easy, the number of buds which fail to grow being very small. At the end of the second year from the time of planting the cuttings, what are in appearance strong young trees are ready for sale. The operation of budding the Bitter orange successfully is comparatively difficult, and the propagation of the stocks entails much more labour and time than in the case of the citron. In consequence of this, young citrus trees which are budded upon the Bitter orange are sold at prices three to four times higher than those which are grown upon the citron, and the latter are planted much

more extensively than the former. Trees which are budded upon the citron grow quickly, they yield more freely when young, and produce somewhat larger fruit than trees which are grown on the Bitter orange. The trees, however, are short-lived and are very subject to the attacks of gummosis and other cryptogamic diseases. It is customary to plant them deeply, in order to cover the point of union between the stock and scion, the object being to induce the tree to throw out roots from above the graft and thus make the orange independent of the roots of the citron. This prolongs the life of many trees, but, notwithstanding this fact, it is common for them to become unhealthy and gradually die at the time when they should be most productive. In point of vigour and resistance to disease, there is no doubt that trees grafted on the citron are very greatly inferior to those grown upon the Bitter orange (Figs. 22, 23, 25, and 26).

Concluding Remarks on "Stocks."

It will be seen from the above notes that the choice of the stock upon which to grow our trees is of importance to the commercial orange-grower. We know that the Bitter orange is a safe stock to use, and its use leads to prolonged success in the cultivation of many kinds of oranges, mandarines, and lemons. Whether the use of some other stock will give better results is not known: very little has been done in this country in the study of the various kinds of stocks with regard to their suitability for different kinds of soil, and their effects on different varieties of oranges, etc. It is in the hope of leading cultivators to make trials in different parts of the country that we have given information regarding certain kinds of stocks which are not in common use in Egypt.

The Purchase of Plants.

The success of any plantation depends upon the health of the plants which are used. Trees which are grafted upon the citron should be used only for temporary purposes. This will be explained later. Unscrupulous dealers often represent those which are budded upon the citron as being budded upon the Bitter orange. This, however, may be detected in two ways. If the bark of the stock is cleaned and slightly peeled with a knife, it will be found to have a yellowish-green colour in the case of the citron (Ar. *Trong*). This yellowish hue does not exist in the bark of the Bitter orange. A little practice soon enables the cultivator to distinguish the two stocks. If any doubt remains after this has been done, the roots of the plants should be examined. Citron stocks are always propagated by means of cuttings, and the roots are spread out from the end of

the cutting. The Bitter orange, on the other hand, is grown from seed and has a main tap-root descending vertically. We have spoken elsewhere of the necessity of avoiding ungrafted trees also.

Having satisfied ourselves that the plants are grafted upon the right kind of stock, the next point to which attention must be given is the strength of the plants. Very frequently, plants are propagated in spare plots in the shade of old gardens. The stocks are weak and attenuated before they are budded, and the resulting orange and mandarine trees are, in consequence, in the same state. In advanced fruit-growing countries, purchasers give attention to the diameter of the stem as much as to the height of the plant. In this country we are obsessed with the idea that the taller the plant is, the better it is. Of course, we must not infer that we should choose plants which are several years old, in order to obtain those with thick stems. The choice of old plants is in fact a very common error on the part of cultivators, especially of those who are engaged in making domestic gardens. Vast sums of money are expended in the purchase of plants which have commenced bearing. Many of these die, and many are thrown into a permanent state of ill-health by being moved so late in life. We must choose stout plants, one or two years old from the time of budding, in order to obtain quick and good results. Needless to say, they should be reasonably free from insect pests. In all cases, it is well to insist on the plants being fumigated before they are taken to the garden or field, even though this measure may not in certain instances be an obligatory one. If the trees are badly affected with scale insects or if they show any signs of being attacked by the Hibiscus Mealy Bug (*Phenococcus hirsutus*), they should be rejected without hesitation.

Until planters learn to distinguish good from bad trees, nurserymen will be able to sell those of inferior quality without difficulty. Inferior trees are sometimes low in price, but they are in no case worth buying.

The only profitable course for the buyer to follow is to obtain good plants, even though he pays comparatively high prices. He should, moreover, remember that it costs more to propagate a strong healthy tree than one which has been crowded with weeds and otherwise neglected.

Owing to the unsystematic manner in which most of the fellaheen propagators conduct their nurseries, it is seldom possible to obtain any but the commonest varieties true to name.

A nurseryman who takes the trouble to keep each variety apart from the others, and who endeavours to deal honestly with his customers in this respect, should be granted the right to charge comparatively high prices as compensation for the cost of labelling his trees throughout the time they are in his nursery.

There is one more point to be emphasized.

A plant which is removed from the ground with a ball of earth of adequate size, weighs more heavily than one with a small ball and proportionately few roots. The transport of the trees with the larger ball is of course more costly, and this consideration leads many proprietors to diminish the size of the ball much below the limits of safety. Unfortunately this is a very common occurrence, so that we cannot too strongly emphasize the fact that the attempt to economize on the cost of transport frequently leads to the death of the plants and consequent financial loss.

In certain districts, the supplier of the trees undertakes to plant them and replace all those which die. Even with these conditions, it is necessary for the landowner to choose his plants, otherwise he will probably find himself the owner of a garden of weak unprofitable trees. The following is a summary of the advice contained in the preceding remarks :—

(1) See that the plants are budded on the required stock.

(2) Do not accept ungrafted plants.

(3) Do not accept plants more than 1·50 metres high.

(4) See that the selected plants have a stout stem and a well-developed head. Such plants are produced only where they have plenty of space and sunlight.

(5) Give as much attention to the roots as to the other parts of the tree.

(6) Do not choose plants more than 2 years old from the time of grafting, or plants which have been grafted on old stocks.

(7) Buy plants which are free of insect pests.

(8) Send your own representative to supervise the work of digging and packing the trees.

(9) Do not economize on cost of transport by reducing the size of the earth-ball on the roots of the trees.

Time of Transplanting.

The season at which citrus trees are most usually planted in the orchard is during the months of January and February. It is sometimes advocated to transplant in the months of August and September. On good loamy land there is nothing to be gained, but much to be lost, by planting at this season. The trees are not resting at that time. A considerable part of the roots must inevitably be lost in moving the trees, however carefully the work is done. Consequently, the shock to the plant is greater in the month of September than in February when growth is suspended. The percentage of plants

which die is greater than in the case of those which are planted in spring. The period of growth which intervenes between the time of planting and the following winter is not sufficiently long to enable the plants to recover from the effects of removal. Any young shoots which are produced are immature and therefore suffer from the cold in winter.

The accumulated effect of all this is to weaken the tree, so that it is not able to make the strong healthy growth which characterizes good trees properly planted in February. The latter therefore make better progress than do those which are planted in September. It will thus be seen that by planting at the end of summer on loamy land we lose time, which we otherwise gain by postponing the work until the end of winter. On the other hand, there are exceptional cases in which autumn planting offers certain advantages as compared with planting in spring. In nurseries which are situated on sand, young trees can be moved with the loss of a much smaller proportion of roots than is possible on heavier land. Land which is composed of sand is warmer than alluvial land, and, consequently, trees which are planted on such soil continue growth later in winter than they do elsewhere. Trees which are planted on sand in autumn, therefore, have a longer period of recovery, and, moreover, the recovery is more rapid than under the colder conditions of good agricultural land. With the exception of the isolated sand *gezîras* which are found in the Delta, land which is covered with drift sand is found only on the edge of the desert. In such a situation, the trees have to support in early summer more adverse conditions in the form of drying winds and flying sand than in autumn. It is therefore better to plant during the latter season, provided that both nursery and field are situated on sandy land. The kind of land of which we are speaking must not be confused with the pebbly soil brought down by the rain and deposited in long stretches, especially at the feet of the eastern desert hills. On this type of land the time of planting is the same as on other alluvial soils. It is sometimes of advantage to the cultivator to be able to plant late in spring, on land from which winter crops have been removed.

Transplantation in spring with naked roots is done between the middle of February and the end of April, but the most suitable time is the last half of February. Trees which are moved in this manner *early* in the season suffer by the circulation being stopped for too long a period. It is better to plant just before the growing season commences, or even *during* the growing season. The tree can thus produce new shoots and foliage as soon as it is planted, and renew at once the processes of life which are to a great extent suspended when the plant is defoliated and moved from the ground.

When trees are moved with a ball of earth, we commence in the

middle of January, but in late planting, *i.e.* in March and April, we have always achieved the greatest measure of success by planting with naked roots.

Method of Transplanting.

Citrus trees are transplanted with a ball of earth attached to the roots, or with naked roots, *i.e.* without any soil on the roots. When they are transplanted with naked roots the trees should be taken up with a long narrow hoe, in order to obtain as many of the roots intact as possible. The common *fass* is a very unsuitable tool for use of this work. As soon as the tree is removed from the ground the roots must be dipped in semi-liquid mud and kept moist until the tree is again planted. Whether the plant is to be taken up with or without a ball of earth, the long branches must be shortened before we commence to dig. If the tree is to be taken up with naked roots, it must be completely defoliated, *i.e.* all the leaves must be removed. This also must be done before the tree is taken from the ground. These two points are practically always neglected. As we have already remarked, buyers, with very few exceptions, estimate the value of a tree according to the length of its stem and branches. They therefore object to the size of the plant being reduced at the time of transplanting, and gardeners and nurserymen are usually in perfect sympathy with the buyer on this point. In the rare cases where the gardener is compelled to shorten the branches, he will often render the operation useless by postponing it until after the tree is dug up. In digging it, the root-system is inevitably curtailed and the plant's supply of moisture is cut off. Transpiration from the leaves continues until they finally dry and wither. The reserve moisture is largely sucked out of the plant, and it arrives at its destination with its bark shrivelled. Is it surprising that so many trees die and so many more grow in a weakly manner after being transplanted ? The latter is perhaps the most serious result, because we continue spending money in the upkeep of unheathly trees. Under moderately favourable conditions, a tree which is properly transplanted recovers quickly and produces strong heathly growth during the first year after being moved.

In digging a tree *with naked roots*, we must start the work as far from the stem as the position of the tree and its neighbours allows. If the plants are standing in nursery rows, we commence digging half-way between the two rows and half-way between one plant and another. This may appear to be an unnecessary observation, but experience soon shows how necessary it is to warn the workmen not to start digging near the stem and thus leave only the stumps of the roots on the tree. Before starting to dig the tree, a hole is made near at hand and filled with semi-liquid mud. The roots of the plant are

dipped in this as soon as they are dug up. The covering of mud helps to keep them moist during their transit to the field. Care must of course be taken that the mud be made sufficiently thick to adhere to the roots. It is useless to fill the hole with water and colour it with a little soil, as is often done. It is necessary to point out that this method of transplanting often leads to disaster in Egypt, even when it is carried out at the right time. In all cases which have come under our notice, however, the disaster has been due to neglect on the part of those who were responsible for the work. The following is a typical case. The trees arrived in excellent condition at the nearest railway station, They remained several days before the owner sent to seek them. Even then they arrived at the field before the holes were ready. On their arrival the gardener commenced to mark the positions of the trees, and as the place of each one was determined he laid a tree on the ground to mark the place. The number of workmen set apart to dig five hundred holes was seven, and no tools were available except *fasses*.

As each hole was dug, the tree was planted, and, meanwhile, the remainder lay uncovered in the field, with all packing material removed and thus exposed to the sun. Needless to say, very few trees survived. On the other hand, where the work is carried out properly, the loss of plants which die is seldom more than five per cent.

By moving trees with naked roots a great saving is effected in the cost of transport. Under certain conditions, it is unwise to transplant in this way, and particularly is this the case where the site of the proposed garden is more or less saline. Trees should there be planted only with earth attached to the roots. We have seen gardens started in this way on land upon which trees invariably died when planted with naked roots.

In digging up trees with earth attached to the roots, it is necessary to use the spade in conjunction with the hoe. A narrow trench is is made around the plant with the hoe, after which the ball of earth is shaped and cut with the spade. For a tree which is one year old from the time of grafting, the diameter of the ball should not be less than thirty centimetres and the length forty to fifty centimetres (Fig. 1). The average weight of such a ball is fifty kilos.

For trees to be successfully transplanted in this manner, the land must be moderately dry. Excessive dryness makes the work very arduous, whereas if the soil is too wet the ball falls to pieces.

For the same reason it is futile to attempt to dig plants with a ball of earth if the soil is sand or light loam. In nurseries which are situated on land of this kind, trees must always be moved with naked roots. On the other hand, trees which are growing on *moderately* compact loam, may be moved either with naked roots or with a ball of earth attached.

Packing and Transport of Trees.

As stated above, the roots of trees which are transplanted without earth attached are dipped in semi-liquid mud as soon as they are moved from the ground. The plants are then bound together in bundles for transport. In making up the bundles, we must avoid the common error of making them too large. Each of them should not contain more than fifteen trees. Larger bundles are unwieldy, and, consequently, the binding cords and packing material are liable to be loosened by the rough handling incidental to transport by road or rail. Another point which requires constant supervision is that of placing the packing straw between the trees.

If left to himself the fellah workman arranges the required number of plants in the form of a bundle, surrounds it with straw and ties it with rope. The interstices between the trees in the interior of the bundle are thus left open and the roots are exposed to the drying influence of the air.

If the straw is moist at the time of packing and the work is well done, trees will, under ordinary circumstances, arrive in good condition at any destination in Egypt, notwithstanding the dry climate of the country. There is generally more danger of injury from dryness than from too much moisture, but, on the other hand, it is not good for the packing material to be in a state of saturation.

In the case of trees which are transplanted with a ball of earth, each one is packed separately. The ball of earth is surrounded with dry weeds or straw, and securely bound with rope (Fig. 1).

In other countries, the ball is surrounded with canvas, but this is a much less effective covering than a good cushion of weeds, and moreover it is more expensive. Rice straw is the best packing material for plants.

This, however, is not always at hand, and although such materials as dried weeds, banana leaves, and pea straw, are more difficult to handle than is the rice straw, they may nevertheless be used without any great inconvenience. The most suitable kind of rope is that which is made of palm-leaflets. This is sufficiently strong without being too expensive. Where this cannot be procured we may use rope made of *halfa* grass.

Trees with naked roots should always be packed in bundles, as explained above, unless they can be transported directly from the nursery to the field. In the latter case, they may be packed in layers of straw in a cart. This course has also been followed in transporting large consignments by rail and boat, but by far the safest course is that of packing the trees in bundles. By doing this we incur no danger of the plants suffering from exposure to sun and air before they arrive at the field.

Trees which are " balled " are packed in " kaffases " or crates of palm-leaf stems. Each crate holds two plants.

Before being packed, the crates must be reinforced with wire to prevent the bottom falling out. This often happens when the crates are used as they come from the maker.

Large consignments of trees with soil attached are packed in carts, boats or railway waggons, with plenty of straw, but without boxes or crates.

Plants which are packed in bundles or in crates may be despatched in railway waggons of mixed merchandise, but trees which are " balled " must be placed in special waggons if no crates are used.

Small consignments may sometimes be transported by passenger train and naturally this is most satisfactory where practicable.

On the principal railway lines, living plants are, however, usually transported by " fast goods " or " vegetable " trains. On other lines, cultivators must depend on the ordinary " goods " train.

Needless to say, plants should always travel in closed waggons, with the usual high open windows. The common practice of despatching them in open trucks with low sides very often leads to the death of the trees.

Another point which is worthy of consideration is the transfer of the plants from one line to another *en route*. If this entails the necessity of moving them from one waggon to another, the proprietor should send his representative to supervise the work. This employee should also be present to supervise the loading of the trees at the station of departure and the unloading at their destination. The railway authorities usually allow the consignor to load the plants where special waggons are employed. In such a case a workman is also permitted to travel on the train to care for the plants *en route*. Although it is not always necessary to make use of this privilege, it is sometimes well to do so as a precaution against delays at junctions.

Bundles of plants with naked roots may be transported by means of camels, but this is a most unsatisfactory means of transport for trees with earth attached to the roots. A large percentage of the balls is invariably broken. Where it is impossible to reach the field with carts, it is well to transplant the trees with naked roots.

As we have already mentioned, trees sometimes arrive at the garden or field before the land has been prepared or the holes made to receive them.

Plants which have been " balled " may be stored in a shed, or they may be placed together in a sheltered place in the open air and covered with canvas to protect them from the sun and wind. Wherever they may be placed, they should be sprinkled heavily with a watering can every day until they are planted.

If the plants have arrived with naked roots, they should be

unpacked and placed in a trench where the roots can be covered with soil. In most cases the gardener digs a hole in which he places the trees without unpacking the bundle. This is useless. The plants must be arranged singly along the trench so that the roots of each may be properly covered with soil, and watered afterwards.

The careful cultivator will, however, study all details of transport and have the land ready to receive the trees on their arrival. Delays are thus avoided which may injure or kill the trees.

Site of Plantation.

Citrus trees may be grown on all kinds of land which are free from salt. The most suitable soil, however, is that which is loose and friable and through which water passes moderately easily. Trees which are planted on *gezîra* or *tamîya* land usually grow most strongly. Heavy clay soils and land which is impregnated with salt are the most undesirable. It is not entirely impracticable to grow citrus trees on such soils, but the expense of preparation is high, the growth of the plants is at the best slow and in the majority of cases unsatisfactory. It is more important to have a loose open soil than a rich soil, which explains why certain plantations situated on comparatively poor sandy land are growing more luxuriantly than others situated on what is more valuable land from the point of view of the cotton-cultivator.

On the other hand, the presence of sand in too great quantities constitutes a disadvantage which cannot be ignored. We recently had to deal with a site where the trees were growing in forty centimetres of light alluvial soil overlying a thick layer of pure sand. The roots of the citrus trees were confined entirely to the alluvial soil, whereas the roots of guava trees growing on the same site had penetrated the sand in all directions. Although citrus plantations exist even on land which is composed entirely of sand, the upkeep of such plantations is necessarily high in regard both to irrigation and manuring.

The distribution of the roots of citrus trees in the soil is not the same in the case of all varieties. The tap-roots of the Bitter orange descend much more deeply than the roots of the citron. This is one of the characteristics of the Bitter orange which make it valuable as a stock upon which to graft other varieties. A moderately deeply-rooted tree is less liable to suffer from occasional lack of moisture than one whose roots are confined to the upper layer of the soil. The *feeding* roots of all varieties of citrus are, of course, spread out in a more or less horizontal direction, but the depth to which they penetrate is greatly influenced by the nature of the subsoil. Where the latter is moderately loose and well-

drained, the roots naturally descend to a greater depth than they would otherwise do.

In a garden at Abu Za'bal, orange trees may be seen growing in soil forty centimetres deep lying upon an impenetrable hard pan. In this case also, the cost of upkeep must be great, and there is always a risk of injury to the trees and crop owing to a temporary breakdown of the pumps or to the negligence of the gardener. Fortunately, the conditions existing in this particular garden are not common in Egypt.

Preparation of Land.

In preparing the sites of orange trees on land which overlies an indurated hard pan of stone-like material, the use of explosives is almost imperative. This will be dealt with in connection with the planting of the trees. On land which is more or less compact, the most important preparatory operation is that of deep ploughing. Shallow ploughing tends to make the feeding roots travel too near the surface of the ground, where they are liable to injury from drought or from the subsequent operations of hoeing and weeding. Land which is poor in humus and plant-food should receive a heavy dressing of farmyard manure before it is ploughed. This is more especially necessary on land which is composed chiefly or entirely of sand. If it is difficult to obtain farmyard manure, a green crop, such as *berseem*, should be ploughed into the land instead of the manure. The elementary principles of land improvement are, of course, known to all agriculturists, but, for the benefit of the amateur cultivator, we may point out that the value of organic materials, such as farmyard manure, street-sweepings or green crops, is not limited by the quantity of plant-food which they add to the soil. On heavy land they help to keep the soil open, and on sandy land they increase the water-holding capacity of the soil. When speaking of farmyard manure we include the manure from horse-stables where straw is used as "bedding." In fact, this form of manure is, in the majority of cases, of greater value than is the *sebâkh beledi* in the preparation of land for tree-planting. We cannot insist too strongly that intending tree-planters should give attention to the preparation of the land to receive the trees. Very frequently we find it neglected on the plea that the ploughing and manuring can be done after the trees are planted. It is, of course, evident that deep ploughing is more difficult upon land which is occupied by trees than upon open land. Moreover, by increasing the ploughing after planting, we increase the danger of breaking and destroying trees. No attempt should be made to establish a citrus plantation on salty land which has not been reclaimed sufficiently to produce a moderately good crop of cotton. Although

citrus trees are more salt-resistant than certain fruit trees such as the apricot, it is not profitable to plant in situations where expenses are unduly high and the yield of trees low. Where it is necessary to make a garden on newly reclaimed land, it is advisable to practise a system of close drainage until it is seen that the trees are growing well. Each line of trees is made to stand near and parallel to a drain. The space between the two lines so laid out acts as a *hôd*, or bed, which is flooded whenever the plants require water. If the reader refers to Figure 8, he will easily understand the arrangement. All kinds of citrus trees grow badly on land which is in a state of saturation for any long period of the year. Mangoes and guavas support such conditions better than oranges or lemons. The latter will grow fairly well in situations where the water-table does not rise above one metre below the surface. Where the conditions are less favourable, they may be somewhat improved by digging trenches, as on salty land, and utilizing the earth to increase the height of the bed or *mastaba* upon which the trees are to grow. This can, of course, be done only where it is possible to raise the height of the irrigation channels in proportion, and in no case can such expedients be employed in commercial plantations.

Before leaving this part of our subject it should be pointed out that, however good the land may be, precautions should always be taken to ensure that the surface is level. Where this is neglected, some of the trees may be planted in depressions. These trees will afterwards receive more than their proper share of water and in consequence grow badly. The land cannot, of course, be levelled after the trees are planted.

Planning the Garden.

The value of good land in Egypt is high, and the establishment of young citrus plantations entails irrigation at all seasons. Continuous irrigation leads to the necessity of frequent hoeing and weeding. These facts make the period which elapses before trees arrive at maturity a trying one to cultivators, and the desire of obtaining the maximum revenues whilst the plantation is still young has led many cultivators to adopt a system of close planting which has been the primary cause of the disappearance of many gardens in this country.

Orange and mandarine trees are planted *and allowed to remain* at a distance of one qasaba (3·55 metres) apart. This space is not sufficiently wide for the full development of the majority of varieties on all kinds of land. The branches of neighbouring trees meet and prevent the access of light, so that very little fruit is borne on the lower of parts the trees. Thus, after a certain time, the amount of the

crop is diminished and not increased by planting the trees so closely, and the maximum yield per acre is never reached. It should always be remembered that fruit cannot be produced where air and light are excluded. Apart from this fact, the custom of spacing the trees closely facilitates the spread of insect pests and leaves no room for the movements of workmen who are engaged in the application of insecticides, in manuring, or in other cultural operations. On the other hand, it may be argued : (1) That plants which stand widely apart suffer more from the hot winds of early summer than those which are sufficiently close together to afford each other a little mutual protection, and (2) that the dry climate, intense light, cloudless skies, and rich soil of this country make it possible and desirable to plant more closely than is done elsewhere. The first consideration applies more particularly to the southern provinces of Aswân and Qena, where much harm is often done by the dry hot winds of spring and summer, for which reason many serious cultivators advocate spacing the trees even more closely than 3·5 metres.

The best way in which to meet these conflicting considerations is to plant the trees sufficiently closely to obtain a reasonable amount of fruit per feddân during the first years of production, and to cut out alternate trees when they increase in size. There is one serious objection to this course, *viz.* the great aversion shown by the majority of cultivators to cut down the temporary trees ; but where there is no hesitation in doing this in good time, the system is undoubtedly the most profitable one to adopt.

The distance apart at which citrus trees are planted at the outset depends partly upon the nature of the land. On heavy land or on poor land, citrus trees do not increase in size so quickly as those which are growing on light or moderately light loam ; consequently certain varieties, if planted one qasaba apart on compact land, bear fruit for several years before it is necessary to remove any of the plants, whereas the same kind of trees which are planted on *gezîra* land usually grow so quickly that they fill the entire space before any appreciable amount of fruit is borne. Close planting in this case therefore leads to a waste of money, in that alternate trees have to be removed before they become highly productive. Especially is this the case in gardens where the trees are allowed to grow naturally without being pruned. If the long shoots which are produced yearly are not shortened, the spread of the branches is greatly extended, although the yield of fruit is no greater than that of pruned trees.

The second consideration in deciding the distance between the trees is that of the variety to which they belong.

Ungrafted trees which are grown from seed always attain a greater size than grafted trees, but the former should not be used in any case, so that we shall not speak of ungrafted plants except in

the case of the Bitter orange and of the lime. The Bitter orange is a tree of narrow upright growth, and even seedling plants may be planted at a distance of 3·5 metres apart. On certain kinds of land, the trees may remain permanently at this distance. Plantations of limes may also be started on a basis of one qasaba apart if budded trees are used, but when the usual course of planting seedling trees is followed they should be placed five metres apart in squares, so that when alternate plants are removed, each tree stands at a distance of about seven metres from its neighbours.

The Italian lemon tree grows quickly and eventually reaches a large size. Even grafted plants should under no conditions be placed 3·5 metres apart. The proper distance and arrangement is that given above for seedling limes.

Varieties of limes and lemons differ very greatly in the rate of growth of the trees and in their size and form at maturity. For this reason, all varieties do not require the same amount of space at maturity. Although it is inadvisable to plant trees of Italian lemon at a distance of 3·5 metres, it is on the other hand wasteful to space trees of the Persian lime more widely than that. Considerable difference in the form and size of the trees is exhibited also by varieties of mandarines. In the case of the variety commonly cultivated in Egypt, the tree has a broad round head, whereas the Santara mandarine tree is erect and narrow in form. Still further differences of size and form are seen in the Satsuma mandarine.

Although such diversity is less marked among the oranges, the differences are sufficiently great to be taken into account in spacing the trees.

The two distances which we have given for lime plantations will be found suitable for other kinds of citrus trees. The lesser distance of 3·5 metres may be used for small trees or in situations where the vegetative growth is expected to be slow. As already pointed out, except in a few cases, these distances must not be regarded as providing sufficient space for the full development of the trees.

For plantations where each kind of tree is planted on a large scale, it is comparatively easy to follow a system of spacing and progressive thinning, which, if adhered to, will leave the permanent trees at the correct distance one from the other. The arrangement must, however, be studied and adopted at the time of planting.

In domestic gardens, where the numbers of trees of one kind may be small, it is frequently impossible to plant each kind at the ideal distance apart, without destroying all uniformity in the garden. In this case, it is better to err by planting too widely apart than by planting too closely together.

Temporary Trees.

The freedom of growth and the ultimate size of a tree is affected by the kind of stock upon which the tree is grafted. The difference between an orange tree which is grafted on the " naring " and one which is grafted on the " trong " is well known in Egypt. Orange and mandarine trees which are budded upon the " trong " or citron, yield more freely when young than do those which are budded upon the " naring " or Bitter orange stock.

This fact, combined with that of their cheapness, marks such plants as being suitable for use as temporary trees in the orchard. They do not grow into large trees and do not live long (Figs. 22, 23, 25, and 26). The last-named characteristic does not detract from their value as temporary trees, because the time for their removal usually arrives before they die, and if they assume a sickly appearance before they are taken away, the owner has no reluctance in cutting them down to make room for the permanent trees which should, of course, be grafted on the Bitter orange, lime or other stock of strong growth. It is not necessary that the temporary trees of a plantation be of the same variety as those which are to remain permanently. Certain varieties are, of course, more suitable than others for use as " catch crop " trees. The Santara mandarine (Fig. 27), when planted between other trees, does not spread sufficiently to interfere with their development. The Sweet lemon of India is also a tree of compact growth, but it is less profitable than the mandarine. The Persian lime and Satsuma mandarine give promise of being useful as temporary plants. Cultivators who wish to intercalate temporary trees of a special kind between the permanent trees of citrus groves, will therefore do well to employ the Santara mandarine when procurable. It is necessary, however, to point out that the Santara mandarine is a variety of comparatively recent introduction to Egypt, and in consequence is not yet widespread throughout the country. Cases will therefore arise in which it will be impossible to obtain plants of this variety in sufficient numbers to be used on a large scale. It is, however, generally easy to procure plants of the Common orange or mandarine budded upon the citron.

Interplanting with Peaches, etc.

The temporary plants which we have mentioned do not reach the fruiting stage much more quickly than the other trees of the orchard. They are therefore useful only in so far as they increase the revenues of the plantation during the first few years *after* the orchard comes into bearing. They do not help the cultivator during the non-productive years which elapse before the permanent citrus

trees commence fruiting. This consideration has led many proprietors to interplant their citrus groves with other kinds of fruit trees. The ones which are chiefly used are the guava and peach. Both of these have the advantage of coming quickly into bearing, so that on good light land some return is obtained even in the second year after planting. The guava grows more rapidly and more strongly than the orange, and as a rule the latter is soon overshadowed. The growth of the orange is arrested, and the guava becomes the principal instead of being the subsidiary tree of the plantation. The same applies to the peach. The peach tree which is used is almost invariably a seedling tree which on light land attains a size little short of that of an apricot tree. It is very often infested with Aphis, which cover both peach and orange with "honey dew," and effectually stops the growth of the latter tree. Apart from the question of size and rapidity of growth, guavas and peaches are objectionable as temporary trees in citrus plantations, on account of the fact that the fruit of both species is liable to the attacks of the fruit fly, which often destroys a large part of the orange and mandarine crop. By planting guava or peach trees between the orange trees, we are providing food and lodging to enable the pest to exist throughout the year in the grove until the orange fruit is ready to receive him. Apricots and apples are also used as temporary trees, but they are both unsuitable for the purpose. The ideal temporary tree should be one which comes quickly into fruit but which does not grow more quickly than those which are to remain. It must also be amenable to pruning, so that any tendency to overshadow the citrus trees can be checked without stopping the fruiting of the temporary tree itself. The pomegranate meets the above conditions, but apart from this there is no tree which is suitable for cultivation as a catch-crop in a citrus grove except citrus trees, either of special varieties or of common varieties budded upon the citron stock.

The cultivator should remember that the employment of temporary trees in a plantation forms part of an intensive system of cultivation which must be practised in *all* respects to be successful. Whilst the roots of a tree are restricted to a limited area, the cultivator must take care that sufficient plant-food for the nourishment of the tree is found in that space. The same is true of moisture. Intensive cultivation necessitates close attention to manuring, watering, hoeing, and pruning.

The cultivator should also remember that the safest and easiest way of developing a plantation is to give trees sufficient space for their full growth from the time of planting. This obviates all danger of injury of one tree by the other. It, however, necessitates on the part of the proprietor the sacrifice of a certain amount of revenue during the years which elapse before the trees reach maturity.

Different Systems of arranging Trees.

There are several ways of arranging trees in the orchard. The principal of these arrangements are known as the square system, the equilateral triangle or hexagonal system, the quincunx system, and the alternate system.

Square System.

For the commercial fruit-grower, the square system is the most advantageous one to follow. The ease with which a field can be divided into squares recommends the system in all countries, and we find that it is employed more commonly than any other wherever fruit-growing is practised on modern lines. In Egypt, where the work of marking the places of the trees and laying out an orchard is done mostly by untrained fellaheen labourers, it is especially necessary to adopt a system of planting which is easy to carry out. The arrangement in squares is illustrated in Figure 9. When the orchard is arranged in this manner, the distance between trees A and B is greater than that between A and C. The square system has therefore been objected to on the ground that the space is not equally divided among the trees. This objection is not made primarily in regard to the space required by the branches of trees; the contention is rather that there must be a certain amount of land not utilized by the roots. The argument, however, is based on the supposition that roots extend in a more or less regular circle around the trunk, whereas, as a matter of fact, they will penetrate in any direction in which they find food, irrespective of the manner of arrangement. The land in an orchard is usually fully occupied with roots, unless the trees are planted more widely apart than is necessary.

The second great advantage of the square system is that trees can be uniformly thinned if at any time this becomes necessary.

When the time comes for the "thinning" to be done, alternate trees—those marked with a circle in the sketch—are removed, thus leaving space on four sides of each of the remaining trees. The latter are now standing in quincunx, *i.e.* in squares with a tree in the centre of each square. If the growth of the trees is such as to necessitate a second "thinning," the centre trees –those marked with a cross in the sketch- are removed, and the permanent trees, B, D, F, H, are left in squares.

Equilateral Triangle or Hexagonal System.

This arrangement is shown in Figure 10, from which it will be seen that all the trees are set at equal distances apart, each tree being

surrounded by six others which are equidistant from it and from each other. This is the only method of arrangement which enables the ground to be divided equally among the trees. It also admits more trees being planted per feddân than in the case of the square system. For the arrangement of *permanent* trees, the hexagonal is the ideal system to employ, but it does not lend itself to any good system of "thinning," except that of taking out three quarters of the total number of trees at one time. If, for example, we remove every alternate line, *i.e.* half the trees of the plantation, the remaining lines are widely spaced, but the trees in the lines remain as close together as when first planted, and, consequently, they have space for further development on two sides only. When the surplus plants are eventually removed, the permanent trees have assumed a more or less flattened shape, instead of the uniform rounded shape which we should aim at producing.

Quincunx System.

The quincunx system is the arrangement of trees by five, A, B, C, D, E, in a square, one (E) being placed in the middle of the square. The arrangement is shown in Figure 11. In this case the distance between any two trees A B in a transverse row is double the perpendicular distance B F between two rows.

Alternate System.

This is the system (Fig. 12) which is most commonly followed in Egypt. The perpendicular distance A B between the rows is the same as the distance A C between the trees in the rows. The distance between the two trees A and D is therefore greater than the distance between A and C. Thus the trees are not equidistant apart, as in the case of the hexagonal arrangement. An orchard which is planted on the alternate system contains fewer trees than one in which trees are planted the same distance apart in squares. In fact, in almost every respect the square and hexagonal arrangements offer advantages as compared with the alternate.

We may also mention that trees are sometimes arranged in rectangles, but, like the alternate system, the arrangement in rectangles leads to a loss of space without offering any compensating advantages.

Arranging the Pegs in Squares and Triangles.

Before we commence to dig the holes in the field, strong pegs must be placed to show the positions of the trees. In order to do this work, it is necessary to have a measuring wire long enough to

stretch across the field, or partly across if it is very wide. The wire is much more satisfactory than rope, because it does not break so easily and is not blown to one side or the other by the wind. Points are marked on the wire at intervals of three and a half metres, five metres, or whatever the distances may be at which the trees are to be spaced. These points are marked with solder, and, if necessary, pieces of coloured cloth may also be attached in order to make the points more visible. At each end of the wire is attached a stout stake to act as a handle upon which to roll or unroll the wire as occasion arises to shorten or lengthen it to suit the width of the field at different points. Other forms of measuring wire or chains may of course be used, but that which we have described is easily made at the farm or village. We first select a straight side of the field to serve as a base line upon which to work. If all sides are crooked, a straight line, J K, is made across the field as near as possible to one side.

Having made a base-line along one side of the field, it is necessary to make side-lines at right angles to the base line. This is done in the following manner :—

A point, L, is first chosen at or near the end of the base-line ; From the point L, we measure a distance of twenty metres along the base-line to M. We then take a piece of thin rope fifteen metres long and describe the arc of a circle with the point L as the centre. After lengthening the rope to twenty-five metres, we describe the arc of another circle with the point M as the centre. The two arcs intersect at the point N and a straight line which runs from L through the point N is at right angles with the base-line J K. If the field is small it it sufficient to make a side-line, B L and K O, at each end of the field, but if the field is large it may be necessary to make one (Q P) or more in the middle of the field, sufficiently wide apart to suit the length of our measuring wire or chain.

On these perpendicular lines we place stakes R, S, T, etc., at intervals equal to the distance at which the trees are to be planted one from the other. The work is then finished by stretching the wire between the opposite points, R R, etc., and placing a peg where each tree is to stand. Placing the stakes to mark the positions of trees in equilateral triangles is most easily done by means of a rope with a loop at each end. We first place pegs along the base-line A B in the field, the distance apart of the stakes being equal to the length of one side of the triangle, *i.e.* the distance between one tree and another. The length of the rope is equal to the length of two sides of the triangle, so that if the trees must be planted seven metres apart, the length of the rope must be fourteen metres. Exactly at the centre of the rope is placed a mark of wire, red cotton, or other material. The line of pegs along the base-line represents the first

row of trees. The loop at one end of the rope is placed on the peg B, and the loop at the other end of the rope is placed on the peg C. We then grasp the rope exactly in the middle and draw it tight at the point D. Here we place a stake, and the three stakes, B C D, make an equal-sided triangle if the work has been properly carried out. To do this, we must use strong stakes and take care not to displace them by pulling too strongly on the rope. To continue our work, we attach the loops of the rope to pegs C and E and place another peg at F. This process is repeated until the whole field is finished. A wooden triangle may be used instead of the rope. The work is done with greater exactitude by this means, but less quickly than by means of the rope. Where trees are to be planted not more widely than 3·5 metres apart, the wooden triangle may profitably be used, but where they are to be planted at a greater distance than this, it is more convenient to use the rope.

The Use of the Planting-board.

The stakes or pegs which we have placed in the fields as explained above, mark the spots where the trees are to be planted; but as it is necessary to remove the stakes before the holes can be dug, measures must be taken to mark the spots, so that the plants may be placed in the right positions afterwards. This is done by means of the planting-board shown in Figure 13. It is made of wood about two metres long and twenty or thirty centimetres wide. A hole (A) is made at each end, and a notch (B) is made in the middle in a straight line with the holes at the ends. Before the stake which marks the position of the tree is taken away, the planting-board is placed on the ground so that the tree-stake fits into the notch in the centre, two other pegs being driven through the end-holes of the board. When this has been done, the planting-board is removed, together with the stake in the centre.

The hole is then dug, and when it is ready, the tree is placed in the middle and the board again fitted on the two pegs, so as to stretch across the top of the hole. The stem of the plant should then coincide with the notch in the middle of the board and thus be exactly in the place of the stake which was removed.

Size of Holes.

In all cases, the holes should be made large enough to afford space for the plants to be removed into their proper positions without breaking the ball of earth attached to the roots, and to spread out the latter if the trees are planted without a ball of earth. On land which is composed chiefly of sand, the hole should be made sufficiently

deep and wide to receive a quantity of black earth and old manure to support the tree during the first year of its life in the field. Although sufficient manure may be given after planting to keep the trees growing, it is of great advantage to them to have some good soil to retain the moisture around the roots until they are established in their new surroundings. It is not advisable to attempt the establishment of commercial citrus plantations on land which is not entirely reclaimed and free of injurious salts, but it is sometimes necessary to make a domestic garden near a house situated on such land. In this case also it is well to make the tree-holes just sufficiently large to allow the tree to be planted.

The Use of Explosives.

On heavy land, the best way of preparing the holes is to break up the soil by means of dynamite or gelignite, but this requires careful supervision. For the information of cultivators who are able to use explosives, we reproduce the following note by Mr. G. S. Crouch from "The Horticultural Review" of November 1915 :—

"The use of explosives in tree-planting is becoming common in many parts of the world. On heavy soil, the preparation of the land by this means offers many advantages over the usual method of merely digging the holes with the spade or hoe. The sub-soil is thus broken and fissured to an extent which cannot be achieved in any other way.

"This ensures the free passage of air and water, and the easy circulation of the roots of the trees. The explosion also sets up certain changes in the soil which enrich it in nitrogenous plant-food. Where explosives have been used in the preparation of the holes, the trees have usually been found to make better growth than those which have been planted in the ordinary manner. Needless to say, explosives are only employed in cases where the subsoil is compact. The explosive most commonly used is that known as gelignite. The operation is carried out in the following manner. A hole about ten centimetres in diameter and about one metre deep is made by means of a soil-borer, a tool which is worked much in the same way as an auger. When the hole is ready, the charge is prepared. The fuse must be cut sufficiently long for one end to project from the hole when the other end is touching the bottom. The ends of the fuse should be cut square across with a sharp knife, or a special cutter which can be obtained for the purpose. The fuse is then pushed gently into the open end of the detonator until it comes into contact with the composition. The detonator is secured to the fuse by being carefully nipped near the open end. A hole is then made at one end of a cartridge and the detonator inserted into this hole, the wrapper

of the cartridge being brought over and tied to the fuse. Two to three other cartridges, after being tied together, are lowered to the bottom of the hole by means of a piece of string, taking care that they are not covered by falling soil and that the " primer " cartridge to which is attached the fuse is placed in contact with the other cartridge at the bottom of the hole.

" When this is done, the holes are gradually filled, the soil being tightly packed with a wooden rod from the bottom upwards. All being ready, the projecting end of the fuse is lighted and the operator retires to a distance of twenty metres. An upheaval of the earth takes place and when the hole is dug it is found that sub-soil is cracked in every direction."

In the great majority of cases, it is impracticable to use explosives in the operations of tree-planting in Egypt, and when it is necessary to plant citrus trees on clayey or compact loam, the best method of preparation is that of ploughing it as deeply as possible, and of making the hole just sufficiently deep to receive the roots of the tree. A hole about sixty centimetres wide and fifty centimetres deep is good. Experience has shown that it is not beneficial to make large holes in heavy land. Even with the exercise of the greatest care to avoid it, the soil becomes beaten and plastered, and the hole is converted into a well from which the water escapes very slowly after the land is irrigated. On light land, or wherever large holes are made, they must be entirely refilled and the land watered before the trees are planted. If it is not watered until after the plants have been placed in position, the latter are almost always thrown out of line by the subsequent settling of the soil.

Planting.

It is necessary to employ two men to plant a tree properly, one to hold it upright and straight, and one to fill in the soil with the spade and the hand. As a general rule, it may be said that trees should not be planted more deeply than they stood in the nursery where they were propagated. As mentioned elsewhere in this pamphlet, trees which are budded on the citron are usually planted deeply, in order to induce the production of roots above the point of union between the stock and scion. This, however, is an exceptional case. It is entirely wrong to plant well-propagated trees deeply. If the trees are received with naked roots, the latter should be spread out horizontally in all directions, and the soil packed around them with the hands. Trees which are received with a ball of earth attached to the roots should be planted without the packing straw being removed. Care must be taken not to break the ball by treading the soil too heavily with the feet. As soon as the tree is planted, the

land is irrigated. Trees which are planted in moderately small holes, or in holes which have been previously refilled and irrigated, will seldom be thrown out of the perpendicular by the final watering. If, however, this does happen, it should be rectified when the land dries sufficiently.

Cultivating Vegetables between Trees.

Even in gardens where trees are planted at the minimum distance of 3·5 metres apart, the farmer in Egypt endeavours to utilize the intervening space for the cultivation of vegetables and other ground crops. As practised by the fellaheen gardeners, this invariably leads to the injury of the trees. The care of the vegetables becomes the main preoccupation of the gardener, and the welfare of the trees is entirely forgotten. He plants a crop of cabbages for example, and waters the land heavily during their growth. The cabbages mature and are removed, after which the land receives scarcely sufficient water to keep the trees alive until the next crop of vegetables is planted. With care and discretion, certain crops can be grown without injury to the trees, but care and discretion are very frequently lacking in the character of the fellaheen gardener. He plants the cabbages close to the stem of the young tree, which is in many cases completely starved and smothered by its robust neighbours. It is not uncommon to see even a crop of maize growing among the young trees. The latter are more or less hidden from view, shoots which arise on the Bitter orange stock are allowed to grow into branches, the graft of Sweet orange or mandarine dies or remains stationary in growth, and naturally the proprietor is disappointed in the progress of his trees.

What we have described is almost universal in gardens which are not supervised by the master or by an intelligent employee.

For the cultivation of ground crops between the trees during the first two years, the land should be laid out in the following manner. Ridges are made parallel with, and not less than seventy-five centimetres from, the rows of trees on each side. The oranges thus stand in the middle of beds 1·5 metres wide, and the space A B (Fig. 14) between the tree-beds may be cultivated with suitable crops. Where this arrangement is followed, the watering of the trees can be regulated according to their own needs. On no account whatever should any crops be sown where the trees are standing. Only leguminous crops should be cultivated. In summer we may sow Lima beans or black-eye bean (Ar. *Lubia*) ; berseem and broad beans are the best for winter, as they prevent the growth of weeds to a greater extent than does the dwarf pea. Moreover, they are more easily sold than is the case with dried peas in this country. As a summer crop, the Lima bean is superior to the black-eye bean, on account of the fact

that the latter is often seriously affected by Aphis in early summer and by Rust later in summer. The last-named pest may be eliminated as soon as a sufficient supply of seed is available of the Rust-immune variety introduced to cultivation by the Ministry of Agriculture; but even this variety will have a more valuable place in other garden rotations than that of a cover crop in citrus groves.

Lima beans are comparatively free from insect and fungous pests in this country. A suitable variety is the Moki Lima, which was first brought to Egypt by Dr. Forbes of the Royal Agricultural Society. Where it is necessary, however, to eradicate such persistent weeds as Halfa grass, a variety of stronger growth than the Moki Lima must be used. That known as the Pe Byu Gya Lima (imported by the Ministry from Burma) has proved useful where the land is infested with strong summer weeds. It is, however, less productive than the Moki Lima (Fig. 15).

Another good variety is the Sieva Pole Lima. Needless to say, the varieties used must be sufficiently vigorous in growth to prevent the growth of weeds, but on the other hand it must not be too rampant.

A plant which produces long leafy shoots soon exceeds its own boundaries and buries the young trees in a mass of foliage. The varieties mentioned above are, however, easily kept within the limits of the bed which the crop is intended to occupy.

The seed is sown in holes about fifty centimetres apart in March or April, the land being watered a few days before being sown.

The beds are hoed once or twice whilst the beans are young; but after this operation the crop receives no further attention, except what is necessary to prevent the plants spreading too widely.

As already stated, a crop of berseem may be sown in winter when the Limas are removed. Such a rotation may be followed during the first two years after the trees are planted. The presence of the crops greatly reduces the cost of weeding, and they yield some revenue during a time when the garden is otherwise non-productive.

It must not be forgotten that although tuberculous leguminous crops are able to provide themselves with nitrogenous food, they take from the soil considerable quantities of potash and phosphorus. The manures necessary to compensate for this loss of plant-food in the land should of course be applied.

In poor land which is still somewhat salty, no attempt should be made to cultivate any crops between the trees.

On heavy land also, the space between the trees should remain free of crops, so that the surface-layer of soil may be kept loose and friable by frequent ploughing. On very sandy land, the most suitable and profitable crop to grow between the trees is the earth-nut (*Arachis hypogea*, Ar. *Fûl Sudâni*).

Tillage.

In a previous chapter, we have spoken of the utilization of the land between the young trees. Apart from the cultivation of suitable leguminous crops, the upkeep of the plantation consists in hoeing the tree-beds, in manuring, watering, pruning, and in the control of pests.

The cultivation of the land when it is free of ground crops is effected by means of the plough and cultivator. These are much more efficacious than the hoe, and should therefore be used as long as the trees are sufficiently small to allow the animals to pass without breaking the branches. After a crop of berseem or beans, the ordinary Egyptian plough with a pair of bullocks is used. The yoke is so arranged that the distance between the animals can be regulated at will.

By increasing the distance, the animals can be made to pass on different sides of the young plant, the yoke passing over it as seen in Figures 16 and 17. For ploughing midway between the trees, the animals are yoked close together. Even in cases where no ground crops are grown between the trees, it is well to plough the land twice a year, in order to bury manure and improve the land as much as possible whilst the trees are small. In addition to ploughing, we must work the surface-soil at frequent intervals by means of a light cultivator. As we have already pointed out, no ground crops should be grown in summer between trees on heavy land which cracks badly. Such land should be tilled after every watering by names of the cultivator. This of course enters the soil less deeply than the plough and is sufficiently light to be drawn by a single ox or horse. When the trees increase in size, a pair of animals cannot be employed without breaking the branches. Moroever, deep ploughing must then be stopped on account of the spread of the roots. A single animal with the cultivator can, however, be used with great advantage for several years between the trees. When the spread of the branches eventually renders its use impracticable, tillage must be continued with the hoe. By that time, the ploughing and mulching of previous years will have brought the surface of the land to a fine state of division, so that the work of the hoe will be comparatively easy. It is, of course, unnecessary to point out that the need of this intensive system of tilling and mulching is greatest on stiff land. The trouble entailed is well repaid in the increased health of the trees and consequent heavy crops.

Many fellaheen gardeners object to use any kind of plough. Weeding and tilling by means of the hoe is very expensive. For this reason, the land is hoed only at long intervals, the weeds flourish and impoverish the soil, the surface of the land bakes and cracks, and, in consequence, the trees suffer. The presence of water furrows, ridges, etc., is quoted as a reason for the non-use of the plough, but the man with a touch of initiative in his character soon finds that

in places where the cultivator can be used, the ridges and furrows can also be made by means of animal labour (Fig. 17).

We have found the cultivator with three flat sweeps, shown in Figure 18, to be most suitable for work in the orchard. In the nursery, however, it is better to use the teeth (Fig. 19).

When working in the nursery with the ordinary plough, the oxen are yoked sufficiently widely apart to allow them to travel along the first and third furrows whilst ploughing the second, *i.e.* the yoke must be sufficiently long to span three furrows. In orchards where the trees are planted in squares, the ground can be ploughed equally well in two directions—from east to west and from north to south—and where the rows are five metres apart, it is practicable to plough in a diagonal direction also. As stated above, where ground crops are grown, the land is ploughed only when the crops are changed. In this case, the tree-beds are hoed by hand, and this must be done sufficiently frequently to keep the land free of weeds and prevent it cracking. It is, of course, an elementary principle of cultivation, that land must not be hoed or ploughed whilst it is wet. By ploughing the land before it is sufficiently dry we do a great deal of harm. This, however, does not apply to sandy land or to very light loams. Where no cover crops are grown, the hoe is used only to clean the land immediately around each tree. Irrigation ridges are usually made by means of the "batana" or ridger (Fig. 20).

In all tillage operations the greatest care must be taken that the bark of the trees may not be injured near the ground. The amount of harm done to plantations in this respect by careless workmen is very serious. We see broken branches, but the cut and bruised bark at the base of the tree in most cases escapes observation until the effects of the injury are noticeable in the dying twigs and falling leaves. It is even better to allow weeds to grow near the stem of a plant, rather than that the bark should be injured by the hoe in the hands of a careless workman.

Manuring.

On the subject of manuring citrus trees, the late Mr. Frank Hughes wrote as follows :—

"When studying the manurial requirements of a crop, there are several points which must be considered. First, we must ascertain what important constituents are removed by the produce which actually leaves the land. In the case of citrus fruits, this, in most cases, will be represented by the fruit alone, as the amount of material removed by pruning is in general very small. Then, it will be necessary to know the character of the root-system. Is it limited or extensive? Is it shallow or deep?

"Analyses of the fruits of the various citrus species show that the elements most extensively removed are lime, potash, and to a smaller extent phosphoric acid and nitrogen. All plants require these substances, but the proportion in which they are absorbed varies greatly with different crops.

"It has been found that the amount of these different substances removed by one hundred fruits is as follows :—

Grammes per 100 Fruits.

	Lime.	Potash.	Phos. Acid.	Nitrogen.
Oranges	20	40	7	31
Mandarines	9	22	7	25
Limes	2	7	1	3·5
Lemons	13	28	5	14
Sweet lemons	7	20	8	20
Bitter oranges	38	52	14	32

"It should be borne in mind that it is in the seeds that most of the nitrogen will be found, and it is therefore desirable to grow fruit with as few seeds as possible and thus avoid a very considerable waste of nitrogen. It will be seen from the above figures, that Bitter oranges are the most exhausting crop, the amounts of potash and phosphoric acid being very considerable.

"Now that we have seen what are the elements required by these crops, it will be well to study the soil from which they are obtained.

"The following analyses of typical fruit soils, one from the Delta and the other from California, will serve our purpose :—

Analyses of Fruit Soils.

	Mit Ghamr.	California.
Loss on ignition	9·33	2·85
Insoluble matter and silica	57·58	75·60
Oxide of iron and alumina	27·31	16·41
Lime	3·80	2·05
Magnesia	1·34	0·94
Potash	0·87	1·24
Soda	0·43	0·26
Sulphuric acid	0·04	0·05
Carbonic acid	1·06	0·08
Posphosric acid	0·35	0·46
Nitrogen	0·078	0·101
Soluble in one per cent citric solution (assimilable).		
Silica	0·324	0·288
Potash	0·022	0·041
Phosphoric acid	0·036	0·186

Mechanical Analysis.

	Mit Ghamr.	California.
Coarse sand	3·8	40·1
Fine sand and silt	19·1	46·4
Fine silt	17·5	6·6
Clay	59·6	6·9
	100·0	100·0

" On both these soils, fruit is grown with success. The chemical analyses show that both soils are rich in potash and in phosphoric acid. Both soils contain a moderate amount of lime; but in the case of the California soil, there is only a very minute quantity in the form of carbonate. This is in all probability due to the fact that heavy dressings of organic manures are applied yearly, and it is well known that such treatment will bring about a reduction of the amount of carbonate and may even cause the soil to become acid. When this occurs, it would be necessary to apply lime in the form of slaked lime or carbonate of lime.

" As regards the amount of assimilable material, we see that the California soil is considerably the richer. This is, in no small measure, due to the heavy and continued manuring.

" The most remarkable feature, however, in these analyses is the extraordinary difference in the physical character of the soils. The Egyptian soil is a stiff black clay soil, drying to a hard clod, whereas the American is similar to the fine silty material met with on the *gezîras* and river banks. This seems rather to point to the fact that as long as a soil is sweet and well drained, fruit will grow.

" If heavy manuring has proved so successful in America, it would be well to try experiments in this country, and since we have smaller amounts or assimilable ingredients present in the soils of Egypt than are to be found in American soils, it is reasonable to expect that satisfactory increases in the yields would result. A mixture in suitable proportions of sulphate of potash, superphosphate or basic slag and sulphate of ammonia would appear to be the most suitable combination. When basic slag is employed, it would be put on the land and ploughed or "hoed in" before the sulphate of ammonia is applied."

The above note is taken from " The Egyptian Horticultural Review " of May 1915. In the same journal for April, 1915, Mr. Hughes comments as follows on the California soil which he had just then analysed :—

" Compared with most Egyptian soils, even those like *gezîra* soil, the sample is much more sandy. It appears to be deficient in carbonate of lime, though very rich in potash and phosphoric acid.

The high value for the available phosphoric acid is no doubt due to the heavy and continued manuring. With so small an amount of organic matter as shown in the loss on ignition, the amount of nitrogen is surprisingly high." Sir W. Willcocks, who brought the soil sample referred to above, stated that in one of the best groves which he inspected in California, the manure applied per acre per annum was as follows :—

Blood	1,290 lbs.	£8
Stable manure	15 tons	„6
Bones	1,290 lbs.	„4
Potash		„1
		£19

The prices quoted are those of pre-war times.

An orange plantation in full bearing removes from the ground in a year more nitrogen and potash than a crop of wheat or a crop of cotton ; but notwithstanding this fact agricultural land is in many cases manured more liberally than fruit gardens. Farmyard manure is used more freely by the farmer than by the fruit-grower. Moreover, in agricultural practice, the farmyard manure is commonly supplemented with artificials, whereas this is rarely done in fruit gardens. In the cotton field there are opportunities each year of ploughing moderately deeply, and thus of aerating and enriching the soil. The land is further enriched by the cultivation of berseem at frequent intervals. In a grove of *adult* orange trees we must not plough deeply nor can we cultivate berseem. The feeding-roots of citrus trees are situated for the greater part in the upper layers of the soil, so that the food of the trees is drawn from a volume of earth no greater than that which is available for deep-rooted plants like cotton. Consideration of the above remarks on manuring leads to the conclusion that citrus plantations must be liberally treated in this respect, and this conclusion is borne out by results obtained in gardens where adequate quantities of manure are used. We must not, however, conclude that the poor growth and low yield of trees is in all cases due only to lack of manure. For the trees to obtain the full benefit of the manure which we apply, the land must be kept free of weeds, and the surface of the land must be kept loose and friable. As we have already pointed out, the physical nature of the soil is of great importance, and we must not expect by the use of manure to make trees grow as strongly on compact land as they do on light loam. To a great extent, the amount and kind of manure must be regulated according to the age and condition of the trees. When they are still young, the object is to encourage the vegetative growth rather than the production of fruit. When they have reached the fruiting stage,

it is necessary to keep the trees growing sufficiently healthily to be able to produce good crops without making excessive leaf-growth. Liberal applications of nitrogenous manures encourage leaf-growth at the expense of fruit-production. Nitrogenous manures may therefore be used in moderation to encourage the growth of plants in the nursery and for young plants in the field. They are also necessary in conjunction with other manures in the general upkeep of the plantations. In the case of one mandarine plantation, we succeeded in restoring vigour to unhealthy trees by dressing with nitrate of soda during the growing season, in addition to the usual application of manure at the beginning of summer. There is reason to believe, however, that an *excess* of nitrogen encourages the attacks of certain fungous pests, by causing the growth of the tree to be too succulent. This applies more to oranges than to mandarines. Excessive supplies of nitrogen are also supposed to increase the amount of fibre in the fruit, to make the skin thick, and to retard the time of ripening. If trees are seen to be growing too strongly, farmyard manure, pigeon manure, dried blood, and all nitrogenous fertilizers should be withheld. Sulphate of ammonia is the most suitable nitrogenous artificial manure for general use. Nitrate of soda dissolves more quickly and may be used where immediate results are required, as in the case of trees which require stimulating in the latter part of summer before the growing season ceases. Nitrate of soda should not be used on salty land. Its place may there be taken by nitrate of lime.

An abundance of potash in the soil is said to have the tendency of decreasing the amount of fibre in the fruit, to increase its keeping qualities, and to make the skin thin.

Although the alluvial soils of Egypt are rich in potash, it is nevertheless advisable to supplement the natural supplies by the use of sulphate of potash. The use of kainit and muriate of potash is not recommended.

Phosphorus is an essential constituent of all plant-food, and one of the three elements which is not always found in sufficient quantities in the soil. It is, of course, useless to apply nitrogen or potash if the phosphorus is lacking in quantity. Where it is in abundance, it appears to counteract the effect of nitrogen by hastening the ripening of the fruit. It may be applied in the form of superphosphate of lime or of basic slag. On land which is composed largely of drift sand, the latter should always be used.

In the present state of our knowledge regarding the manuring of fruit-trees in Egypt, it is impossible to do more than lay down general rules for the guidance of the cultivator. The subject is under investigation, but it will be some years before the trials which have been instituted give sufficient information to enable formulæ to be made for the manuring of each kind of citrus trees.

The formulæ given below have been prepared by Mahfuz Eff. Rizk. They are based on the composition of the four most common types of land found in Egypt, considered in conjunction with the needs of citrus trees generally. In any case it will always be necessary for a cultivator to adapt any given formula to the condition of his own plantation. It is well to retain a few rows of trees upon which to try modifications of the system of cultivation usually followed in the garden. For trees which have not reached the bearing stage, use half the quantity of ammonium sulphate, one-third the quantity of superphosphate, and one-third the quantity of sulphate of potash recommended for an adult tree.

FORMULA No. 1.

(For trees growing on land composed of drift sand, such as exists at many places on the edge of the Western Desert and elsewhere.)

Quantities per Tree.

	Trees 3·5 Metres apart.	Trees 5 Metres apart.	Trees 7 Metres apart.
	Kilo.	Kilo.	Kilo.
Superphosphate of lime	0·500	0·750	1·000
Sulphate of potash	0·300	0·450	0·600
Sulphate of ammonia	0·400	0·600	0·800

FORMULA No. 2.

(For trees growing on the sandy pebbly soil deposited by rain water in many places on the edge of the desert.)

Quantities per Tree.

	Trees 3·5 Metres apart.	Trees 5 Metres apart.	Trees 7 Metres. apart.
	Kilo.	Kilo.	Kilo.
Superphosphate of lime	0·450	0·625	0·900
Sulphate of potash	0·200	0·300	0·400
Sulphate of ammonia	0·300	0·450	0·600

FORMULA No. 3.

(For use on the silty land of the islands and river banks.)

Quantities per Tree.

	Trees 3·5 Metres apart.	Trees 5 Metres apart.	Trees 7 Metres apart.
	Kilo.	Kilo.	Kilo.
Superphosphate of lime	0·350	0·525	0·700
Sulphate of potash	0·100	0·150	0·200
Sulphate of ammonia	0·250	0·325	0·500

FORMULA No. 4.

(For use on heavy loams upon which cotton is usually grown.)

Quantities per Tree.

	Trees 3·5 Metres. apart.	Trees 5 Metres. apart.	Trees 7 Metres apart.
	Kilo.	Kilo.	Kilo.
Supersphophate of lime	0·350	0·525	0·700
Sulphate of potash	0·050	0·075	0·100
Sulphate of ammonia	0·250	0·375	0·500

To enable cultivators to use fertilizers not mentioned in the tables given above, we give the following list of equivalents:—

100 kilos. nitrate of soda = 77 kilos. ammonium sulphate.
100 kilos. nitrate of lime = 65 kilos. „ „
100 kilos. cyanamide of lime = 100 kilos. ammonium sulphate.
100 kilos. dried blood = 50 kilos. ammonium sulphate + 37 kilos. superphosphate of lime.
100 kilos. "Poudrette" (best) = 10 kilos. ammonium sulphate + 20 kilos. superphosphate of lime.
100 kilos. pigeon manure = 25 kilos. ammonium sulphate + 17 kilos. superphosphate + 5·5 kilos. sulphate of potash.
100 kilos. sheep manure = 3·5 kilos. ammonium sulphate + 4·5 kilos. superphoshate + 0·6 kilos. sulphate of potash.

The utility of farmyard manure in not confined to the supply of plant-food to the soil. On sandy land, it increases the water holding capacity of the soil. It also improves the texture of heavy land and prevents the soil cracking after being watered. In this respect, manure from horse-stables is better than the ordinary *beledi* manure. The use of the stable manure for "mulching" purposes on heavy land should always be kept in mind. Where an adequate quantity is mixed with the surface-soil, it greatly decreases the amount of tillage required to keep the soil friable. Old *tibn*, screened street-sweepings, etc., may also be used for this purpose. On sandy land, the manure should always be buried as deeply as can be done without destroying the roots of the trees.

Many fellaheen gardeners apply all kinds of manure by burying it in a hole as near to the trunk of the tree as possible. This is entirely wrong. In the case of adult trees, it is not necessary for the manure to be placed nearer than 60 centimetres from the trunk. Needless to say, it should not be placed in a hole, but be spread uniformly around the tree to a distance equal to the spread of the branches. Nitrate of soda should not be mixed with superphosphate. These manures should be applied in separate dressings. Neither should nitrate of soda nor sulphate of ammonia be mixed with organic manures. When used together, they should be applied at different

times. There is some difference of opinion as to whether it is better to manure citrus orchards once per year, or to give half the manure in January and half in June. Most of the evidence points to the fact that it is well to give the annual manuring towards the end of January, *i.e.* before the first watering and before the growth of the trees commences. Additional quantities of nitrogenous manures are given throughout the summer if the appearance of the trees shows that they require it.

We have already pointed out the necessity of the cultivator being guided by the condition of his trees in the application of manures. He will also find it useful to have samples of the soil analysed at intervals of not more than two years. If it is found that there is an excess of any constituent, the amount of that element applied as manure is of course decreased until the balance is restored.

Irrigation.

The methods of irrigating trees are regulated to some extent according to the kind of land upon which they are growing and the fact as to whether the water is pumped or obtained by gravitation from a high-level canal. The necessity of pumping water imposes the need of economy, and this influences the method of distribution, especially on sandy land. In cases where beans are cultivated between the young trees, the latter stand in narrow beds as already explained.

These beds are filled with water and the trees irrigated according to their needs. The space between the tree-beds is likewise watered according to the needs of the beans or clover which occupy the land.

This can be done on all kinds of land. In cases where crops are not grown between the trees, the same system may be followed, the tree-beds only being irrigated when the pumps are working, and the whole surface when free-flow is available. Even where all the water has to be lifted, it is necessary to irrigate the land between the tree-beds at intervals of a month or six weeks. On all kinds of land this is necessary to enable the roots of the trees to spread outwards, and in many places it is necessary to prevent the salt rising to the surface. The existence of narrow tree-beds, however, enables water to be economized when the irrigation of the intervening space can be dispensed with. As trees increase in size, the roots spread throughout the whole area of the land. It is therefore imperative that moisture be evenly distributed throughout the whole area. This may be done by arranging the land in beds, and flooding the entire surface. The size of the beds or basins should not be too large. Beds, each of which contains four trees, are the most workable on black land, especially if the distance between the trees does not exceed five metres (Fig. 21).

The basin system of irrigation involves the use of a large quantity of water, and where the supply is limited, it is necessary to adopt the furrow system. This consists of channels parallel to the rows of trees. One large channel between two rows of trees may suffice, but if it is found that the water does not moisten the soil as far as the trees two channels should be made. This depends (1) upon the nature of the land, (2) upon the distance between the rows, and (3) upon the age of the trees. Where three channels are necessary when trees are young, one or two may suffice when they become older.

Irrigation by means of furrows offers certain advantages as compared with basin irrigation. Where the latter system is practised, there is a danger of watering too heavily at times when it is desired to water lightly, as, for example, during the season of flowering. In the case of trees which are *not* grafted on the bitter orange stock, it is inadvisable to allow the irrigation water to come into contact with the stem of an *adult* tree, and thus create conditions favourable to the spread of the "mal-di-goma" disease. Where the furrow system of irrigation is followed, the water rarely touches the stem of the tree ; but where the basin system is practised, it is difficult to prevent the approach of the water. On the other hand, if the land is at all salty, it is better to use the basin system ; and even where the furrow system is used, it is well to give a heavy watering once each year and allow the water to flood the entire surface of the land. This should be done early in spring before the trees come into flower. Another point which is worthy of consideration is that basin irrigation ensures a more even distribution of nitrogenous plant-food in the soil than does the furrow system. The distance which water is allowed to flow in an irrigation furrow or narrow tree-bed from its inlet is a matter of importance. The greater the distance from the inlet to the end of the flow the more uneven is the distribution of the water, the trees near the inlet receiving more than those at the end. Short furrows also have the advantage of mitigating the ill-effects of any inequalities in the level of the land. On light soil the length of the flow should be shorter than on land of a more compact nature, but even on cotton land it is not well for the length of the furrow to be more than thirty metres. This of course necessitates the existence of larger feeding-channels at intervals of sixty metres running at right angles to the tree rows. These larger channels bring the water from the main canal and distribute it on each side along the furrows for a distance of thirty metres as already explained. The distribution-furrows should be below the level of the surrounding land, and should not be formed by raising the earth on each side above the ground level. The water thus enters easily from the higher feeding-channels, and less of it is lost in the surface-soil than is the case when the furrows are above ground level. In width, they should not be less than

seventy-five centimetres at the top. When it is desired to give a light watering, they are of course only partially filled. Owners who depend entirely upon the agricultural irrigation rotations, must water their trees at the times fixed by the Irrigation Department. These rotations are such that the upkeep of established plantations may with good management be carried on with success on land of moderate density. Nevertheless, the presence of a well from which water can be drawn without restriction as to time or quantity will always be found of great assistance. In the nursery, it is an absolute necessity.

In many situations, it is an absolute necessity, even for the upkeep of adult trees, and it is almost a necessity in the case of newly planted trees on whatever kind of land they may be situated.

These require water at short intervals during the first summer in the field, and where irrigation has to be supplemented by water in tins or buckets the results are usually less satisfactory than they would otherwise be. Neglect in watering newly planted trees is, however, not always due to lack of facilities. At the time of writing this note, a case has come to notice of cotton being sown immediately after the trees were planted, the latter being subjected to the period of drought usual in the cultivation of cotton in its early stages.

Such treatment naturally leads to the death of a large percentage of the trees. On the other hand, cases have come under notice where, on low heavy land, the growth of the trees was entirely stopped by too frequent irrigation. The danger of keeping the plants too dry is of course greatest on sandy land. The intelligent practical cultivator, however, does not give water without previous examination of the soil and plant. In Lower Egypt, fruit-bearing plantations of oranges and mandarines on black land are not watered in December and January. This first watering of the year is given towards the end of the latter month. A second watering is given towards the end of February, and a third watering at the end of March. During the flowering period, the greatest care is required in watering.

Excessive moisture or dryness at this time causes the flowers and young fruit to fall. A heavy watering after a period of comparative dryness has the same effect. Our efforts should be directed towards the maintenance of a uniform state of moisture at this season. If the ground become too dry, give a light watering. It is better to give two light waterings at moderately short intervals than one heavy watering whilst the fruit is small. After this stage is safely passed, the trees are watered at periods of eighteen to twenty days throughout the summer. On high sandy land, irrigation cannot be stopped in winter, nor during the flowering period. The intervals between the waterings in summer must also be greatly reduced to seven days or even less. On the other hand, on low heavy soil, the periods may be lengthened to thirty days or more. In Upper Egypt,

irrigation cannot be stopped in winter on any kind of land, and it must be much more frequent at all times of the year than in Lower Egypt.

All kinds of citrus trees do not require the same kind of treatment in regard to watering. The Santara mandarine is much more resistant to drought than the Egyptian mandarine, and consequently can be grown on high light land where the Egyptian mandarine fails. It will not, however, support the prolonged periods of drought to which the Egyptian lime is subjected. The Sweet limes and lemons withstand drought well, but it is not advisable to subject them to the system of irrigation adopted in the cultivation of the acid limes and lemons. In the case of the Sweet lemons, we require the fruits as early as possible in autumn, whereas acid lemons sell much better in early summer than in winter. Sweet lemons may therefore be irrigated like oranges, but acid lemons and limes are subjected to special systems of irrigation, in order to increase the production of out-of-season flowers and fruit. The irrigation of the ordinary lime and Italian lemon will be dealt with in paragraphs devoted specially to these varieties. The intimate relationship between the various operations of tillage, mulching, and watering has already been emphasized.

Trees grow well with the application of comparatively small quantities of water, if the land is frequently tilled and well mulched, whereas they may grow badly if the land is allowed to crack, even though comparatively large quantities of water are given. It should also be noted that the presence of a good supply of available plant-food enables trees to grow well with the help of less moisture than they require on poor land. Good tillage and sufficient manuring therefore enable us to economize water if necessary, and the best results cannot be obtained by the use of a great deal of water only, without due attention being given to the tillage and manuring of the soil.

Pruning.

This is an important operation which is entirely neglected in this country. No plantation can be successful if the trees are allowed to grow naturally without any control or help from the cultivator. Under these conditions, they form long branches with a minimum number of fruit-bearing growths. The tree thus assumes an irregular open form with a small number of flowering shoots and with branches which are too weak to support the weight of the fruit which they bear at the ends. By pruning each year the strong branches which project beyond the general outline of the tree, a regularly shaped head is formed, full of small fruit-bearing shoots.

Such a tree does not occupy as much space as one which is allowed to grow naturally, and moreover it bears heavier crops. Being regular in shape, it is more easily treated with insecticides, and the fruit is more easily gathered. No attempt should be made to create a tree with a long stem. The branches are allowed to arise at a height of fifty centimetres. When the plant is young, the first branches may be allowed to hang to the ground. The first crop of fruit is borne on these lower branches. As the tree increases in size, they are removed, in order to leave a space in which the air can circulate freely below the tree. There are thus four operations of pruning : (1) cutting off or shortening irregular shoots on young trees, in order to form the shape of the tree when young ; (2) shortening long shoots on adult trees in order to induce the formation of fruit-bearing shoots near the body of the tree. Otherwise the fruit is borne at the ends of these long shoots, where it suffers from the action of the wind ; (3) cutting out branches which trail on the ground in the case of adult trees ; (4) cutting out dead twigs and branches. We do not insist on the more technical forms of pruning. Cultivators will soon evolve their own system, once they realize the value of the operation in its most elementary forms. All kinds of citrus trees do not require the same treatment. Italian lemons and Egyptian sweet lemons require more pruning than the Indian sweet lemon or the Persian lime. The Common lime does not require much pruning ; neither does the Egyptian and Santara mandarines. Most of the oranges produce long shoots which require shortening, as already explained.

Pruning should be done as soon as the crop is removed from the trees, provided they are not then in flower. In certain cases, it must be done when there is young fruit on the trees. Needless to say, in these cases, the work must be done very carefully, in order that the fruit may not be damaged or knocked off. Generally speaking, the best time at which to do the pruning is the end of January, but this may be modified by the fact of ripe oranges or lemons being left on the trees for sale late in the season. Pruning may be done with a pair of *sécateurs*, but all care must be taken to leave no broken or lacerated ends where decay may commence. It is also necessary to burn all dead branches as soon as they are removed, as they frequently harbour insects and other pests. Temporary trees are always pruned more heavily on all sides than permanent trees, when the time approaches to remove the former. For two years before the temporary trees are removed, the side branches are shortened, so that the permanent trees have plenty of space. In this way, the temporary tree is gradually reduced to a skeleton, the final removal of which does not cause any regret to the proprietor.

Gathering the Crops.

Notwithstanding the enormous increase within recent years of the areas now devoted to the cultivation of citrus fruit in America, South Africa, Australia and Mediterranean countries, there appears to be no diminution in the profits derived by the growers from their plantations. Seeing that the world's production is still below the point of over-supply, there is no reason why Egypt should not become an exporting country. It is not probable, however, that this will take place in the immediate future, and we shall therefore not describe the details of packing and preservation for foreign markets; but there is one point which should be emphasized. No matter where the fruit is to be sold, it should always be cut from the tree with a piece of the twig attached. The custom of pulling the oranges away from their stalks is injurious to the tree and detracts from the keeping-qualities of the fruit. Needless to say, the careful workman will take every precaution to prevent the bruising of the fruit when it is being gathered. The practice of shaking the branches and allowing the fruit to fall to the ground should never be permitted. Special tools for use in gathering the fruit on the higher branches may be purchased very cheaply. One of these is represented in Figure 33. The earliest oranges to come into the market are the Sugar orange and the Navel orange. These appear in the month of October; mandarines arrive somewhat later. The Mediterranean, Jaffa, and blood oranges may remain on the trees until the month of May, when prices are always high, notwithstanding the competition of the imported Jaffa oranges at that season. An orange tree may be expected to give an average yield of twelve fruits in the third year, eighty in the fifth year, 140 in the eighth, and 260 in the tenth year. The Mediterranean orange bears more freely than other varieties. The Navel and Jaffa oranges bear most sparingly of all. The common mandarine tree bears an average of 15, 150, 300, and 500 fruits in the third, fifth, eighth, and tenth years respectively.

Before sending citrus fruits to market, they should always be graded into two or three sizes. The most usual course is to send them to market just as they come off the trees. The merchant who buys them assesses the value of the whole consignment according to the value of the lowest grade fruits in the consignment, whereas if they have been graded the seller may expect to get good prices at least for the fruits of first class size and appearance. No effort should be spared to render their appearance attractive by brushing off all dirt and dust adhering to the kin. In other countries, this work is done by means of machines. Such a machine should find a place in the equipment of citrus plantations in this country also.

Fungus Pests.

We have already referred to the disease known as "mal di-goma," collar-rot, or foot-rot. This attacks the stem of the tree near the ground and the main roots near the stem. The first indication of the presence of the illness is the exudation of the drops of gum from the bark on the diseased parts. The bark and the wood immediately underneath soon decay, and the trees become unhealthy and eventually die. The cause of the disease is not known with certainty, but it is generally accepted that trees which have their bark injured in any way are more easily infected than others. Every precaution must therefore be taken to prevent the bark near the ground being bruised by workmen or animals. A wet sodden state of the soil also favours the spread of the disease, so that we should also guard against over-watering the trees, especially on heavy land. To arrest the spread of the disease, the earth is carefully removed from the base of the tree and all affected parts of the bark and wood are cut away with a sharp knife. The wound is then dressed with Bordeaux Paste. To make Bordeaux Paste, dissolve two kilogrammes of copper sulphate in fifteen litres of water, in a wooden or earthen or glass vessel. Slake four kilogrammes of lime—the lime must be of the best unslaked lumps—in fifteen litres of water, in a separate vessel of any kind. Then mix the two together. A light blue mixture is formed. All the diseased tissue which is cut out should be burned, and the hoes and knives which are used in the operation dipped in boiling water. Trees which are grafted upon stocks of bitter orange are seldom affected with "mal-di-goma" if they are properly planted. The practice of covering the points of union between the stock and the scion with soil is, however, calculated to minimize the resistant properties of these trees, and should be avoided.

As we have already pointed out, they should not be planted at a greater depth than that at which they were standing in the nursery.

Trees which are grafted upon the citron stock, and sweet orange trees which are grown from seed, are most frequently attacked by "mal-di-goma."

There is a disease known as Brown Rot Gummosis, which is caused by the fungus *Pythiacystis citrophthora*. Tewfik Eff. Fahmy states that "the infection usually starts at the base, or just above the base, of the tree, and works rapidly upwards and sideways. It causes large quantities of gum to exude from the affected areas. The bark splits longitudinally, but remains fairly firm. There is a great similarity between this disease and 'mal-di-goma,' and they are scarcely distinguishable. But generally speaking, in 'mal-di-goma' it is the crown that is mostly attacked, while in this disease the bark on the trunk is the affected portion. The same treatment applies here as in 'mal-di-goma.'"

What is known as "wither-tip" is another common disease of trees in Egypt. This is due to a fungus known as *Colletotrichum gloesporioides*.

In "The Agricultural Journal of Egypt," Volume III, Part I, page 28, Mr. B. G. C. Bolland wrote as follows :—

"The fungus attacks most citrus fruits, but is particularly common on orange trees.

"*Symptoms.*—The disease can be most readily seen on the stem, but the leaves and fruit are also attacked.

"The top portion of the stem dies and becomes greyish-brown in colour and is separated from the healthy tissue by a very distinct line or ring.

"That line or ring is a very distinct character and is an almost unmistakable sign of the presence of the disease.

"On the dead portion of the stem small greyish spots will sometimes be visible ; they are composed of the minute spores of the fungus, which get blown about by the wind and so infect other trees.

"On the leaves the symptoms are much the same as those on the stem, for greyish-brown patches appear, which, after a time, become torn, and irregularly shaped holes are formed.

"On the fruit brownish patches are formed which develop into cracks.

"However, it is on the stem that the disease is most common and can be most easily recognized. . . .

"*Control of Disease.*—It can be held in check by spraying with Bordeaux Mixture, but the best and safest way of getting rid of the disease is to cut off the diseased stems five centimetres below the characteristic line or ring, and then burn them.

"Any diseased leaves and fruit should be collected and burnt.

"The trees should be kept in as healthy a condition as possible by good cultivation and a proper supply of nourishment and water. Trees which are not properly looked after are always more liable to get diseases than those which are treated in the right way."

Wither-tip is usually worst on wet or badly drained soils, and also on land which has been heavily dressed for some years with farmyard manure. When this disease appears, the use of nitrogen-containing manures should be discontinued for a time, and care taken not to over-water the trees.

On two occasions, the orange trees at Giza have been attacked by a disease which caused the death of isolated branches on many of the trees. The following letter from Tewfik Eff. Fahmy, who examined the trees on the second occasion, gives details of the symptoms :—

"I have examined the wilted orange twigs sent here on December 6, 1922. I failed to discover any fungus responsible for the disease. Externally and internally, the stem had no abnormalities,

but appeared healthy. The foliage was wilted uniformly throughout the affected branch, some were still hanging on, others had dropped off."

This disease is not Exanphema or Die-back, which is characterized by gum-pockets, excrescences and multiple buds on the branches, dying back of the branches, etc.

These symptoms were absent in this case, but those present resembled somewhat those described by S. Fawcett (University of California Publications, Bull. 262 : " Citrus Diseases of Florida and Cuba compared with those of California." He gives under " Citrus Blight " the following symptoms :—

" Usually a wilting of the foliage as if the tree was suffering from drought. Usually this occurs in the early spring and appears most pronounced on dry hot days, but later this wilting continues throughout wet weather. Most frequently a single limb near the top will show signs of wilting, after which this condition will spread to the other branches. As the disease progresses, the leaves often drop off, or in some cases the wilting may occur so suddenly that the leaves will remain hanging on the twig. After the top has been injured, numerous water-sprouts put out from the trunk and larger limbs. These appear healthy at first and seem to give promise to a new healthy tree, only to sicken and die later. In most cases of blight, the roots appear healthy. A great deal of time has been lost in trying to grow new tops on blighted trees."

A great amount of scientific study and investigation has been done upon this disease, without so far finding anything that could satisfactorily explain the cause of the trouble.

Few branches among those sent showed Die-back. When the trees were examined in the field, these were few, relatively to the others resembling blighted twigs.

It is interesting to note that in Florida the cause of Die-back, which is considered to be a physiological derangement of the vital functions caused by irregular or improper food and moisture supply, has been fairly well established. It has been found to be due to an excess of ammonia in the soil resulting from the application of excessive organic manure.

The question to be asked is : Is the cause of blight somewhat similar to that provoking Die-back ? If so, can blight be prevented ?

Lipman has recently suggested that the direct cause may be an abnormally slow nitrification in the soil, accompanied by rapid amonification, thus forcing the plant to take up ammonia compounds.

Under ordinary conditions, when ammonia is produced in the soil, it combines with calcium and forms ammonium carbonate, which alone can be attacked by the nitrification organism.

Will the addition of lime to heavily manured orange groves

(organic manure) assist to prevent blight and Die-back in this country ? It is a known fact that lime will reduce the alkalinity of the soil and render conditions physically, chemically, and biologically suitable for the plant.

Lichens.

In some districts lichens constitute a serious pest in orange groves. The grey crumpled growths sometimes increase to such an extent as to entirely cover the branches of the trees, from the trunks to the small shoots. The trees are of course soon choked and killed. Fortunately it is not difficult to prevent the spread of lichens, if the cultivator will take the trouble to scrub the large branches with soap and water, and spray the leaves with Bordeaux Mixture made in the following way :—

Copper sulphate	3	kilogrammes.
Unslaked lime	1·5	,,
Water	100	litres.

The copper sulphate is dissolved in a glass or wooden vessel containing six to seven litres of water. It takes twenty-four to thirty hours to dissolve. The lime is then slowly slaked with a small quantity of water in a bucket. The remaining quantity of water is afterwards added to the lime in a large tub. The copper sulphate solution is then poured into the lime water, which is stirred strongly. The mixture must be strained through muslin or wire mesh, before being placed in the sprayer. The solution may be tested by immersing the blade of a knife in it. If a red precipitate appears on the blade, more lime must be added to the mixture. No iron vessels must be used in making it.

Rats.

A great deal of harm is occasionally done to citrus trees by rats, which build their nests in the branches and gnaw the bark off the branches. Apart from the usual means of exterminating the rats by means of cats, dogs, traps, poison, etc., it will often be found useful to cut out a few branches and thus admit light into the centre of the tree. The rats dislike this.

Mixed Gardens.

Many cultivators endeavour to turn their orange groves into ornamental gardens by planting roses and other flowering shrubs on the sides of the roads. This practice is most pernicious and should not be attempted, as the presence of the ornamental plants makes the task

of keeping the plantation free from scale and other injurious insects most difficult. If citrus trees are planted as a source of profit, they should not be mixed with other trees. Fruit may be grown in mixed gardens for domestic use if necessary, but a commercial plantation should consist of one class of fruit only. The vineyards of Abuxah and Mît Ghamr, the fig plantations of the Faiyûm and Beltan, and the apricot plantations of El Amar, would be entirely unprofitable if mixed with other kinds of plants. Groves of different kinds of fruits may be planted, but the extent of each should be sufficiently large to reduce the working expenses to a minimum. The produce is more easily sold if there is a large quantity of one kind to attract wholesale merchants to the district. In other respects, it is much safer to plant a moderate-sized area with oranges or mandarines than to plant several kinds of fruits on the same area. In the former case, the proprietor and his workmen can give their whole attention to the cultivation and the watering of that particular crop, before making trials with other kinds. Small gardens planted with many different kinds of fruit will never yield large profits, and in many cases the returns are not sufficient to pay expenses.

Wind-breaks.

Fruit-trees which are exposed to high winds do not grow well. Young shoots are scorched in spring, and flowers as well as fruits are blown to the ground when they appear.

Wind-breaks must, as a rule, be composed of evergreen trees, such as casuarina, eucalyptus, cypress, and sycamore. The leafless branches of deciduous trees are not sufficiently dense to stop the wind effectively in winter. At the same time, it is a mistake to think that a tree which is not of a compact growth is useless as a wind-break. Such a tree as the Jordan willow makes an excellent wind screen, not so much by turning the current of air upwards and causing it to pass over the garden, but by breaking the force of the current among its numerous branches and leaves. For gardens of a small area, the Jordan willow makes an excellent wind-break, although for large gardens a taller tree is required. The use of large-spreading trees, such as the sycamore and Aleppo pine, for the formation of shelter-belts is of course restricted to situations where there is ample space for the trees to grow on the windy side of the garden. Where the space is available, such trees undoubtedly form the best wind-screens. In the majority of cases, however, it is necessary to use a tree which does not spread so widely.

Eucalyptus requires less space than the sycamore, and the cypress less than the eucalyptus. The *Atl* or *Abl* (*Tamarix articulata*) is one of the best trees for the formation of wind-screens.

The cost of establishing a wind-break of tamarix is small, because the cuttings may be planted where the trees are to grow.

They grow moderately quickly and are suitable for cultivation on almost any kind of land. In no case must the shelter-trees be planted at a less distance than seven metres from the nearest fruit-trees, and where large trees with spreading branches are used the distance must be much greater. Fruit-trees as a rule suffer less from partial shade than annual crops, such as cotton. Nevertheless, it is necessary to guard against the branches of the shelter trees overhanging the fruit-trees, and for this reason it is often necessary to shorten or entirely remove branches on the side next to the garden. Naturally the shelter-trees need not always be planted within the garden boundaries. They may often, for example, be planted along a road parallel with the garden fence, where they may serve the double purpose of shading the road and sheltering the garden. A single line of trees is usually sufficient to form a shelter, but in districts which are greatly exposed to high winds from the sea or desert, it is often necessary to plant two or more rows, especially in the case of casuarina. This is necessary not only to make the shelter more effective but also to give the trees some mutual support against the wind whilst they are still young. In fact it is sometimes necessary to plant a line of *ghab* (*Arundo donax*) or erect a fence of reeds in order to shelter the trees until they are established.

In the case of large gardens or fruit plantations, it is not sufficient to make a wind-break on the boundaries only. Other lines must be planted at intervals of 80 to 100 metres throughout the plantation so that the wind currents may be diverted upwards and so prevented from sweeping through the crops below. The lines of shelter-trees are planted in a direction at right angles to that of the prevailing wind, and they are planted on two or more sides, or in more than one direction in the garden, if the injurious winds in the district come from different points of the compass at different seasons. This applies to land where crops require protection from blowing sand, as well as to gardens which require protection from wind only. Trees with soft leaves cannot support the contact of moving sand, for which reason it is always necessary to use those which have narrow tough leaves, such as the eucalyptus and Australian wattles, in districts where sand-storms prevail. The tamarix, casuarina, cypress and Aleppo pine are also adapted to support such conditions. On no condition should trees such as *Eugenia Jambolana* and *Ficus retusa* var. *nitida*, which are usually infested with scale insects, be planted as wind-breaks. Mango trees are also subject to the attacks of the orange scale. In the adult stage, they are too large to be easily fumigated, and although the trees may resist the effects of the attacks with little apparent injury, they are often a serious source of infection to the

citrus trees which are much less resistant. For this reason it is well to separate our mango trees as far from the citrus grove as possible. In Upper Egypt it is sometimes recommended to plant Poinciana at intervals of twenty-eight metres throughout the planta tion, in order to protect the oranges from the scorching rays of the hot sun.

Hedges.

Another necessity of the fruit garden is a good hedge, to prevent the ingress of trespassers and thieves. One of the most effective plants in this respect is *Caesalpinia sepiaria*, which is covered every-where with recurved spines. It therefore makes an impassable barrier. On account of its extreme freedom of growth, it must be clipped at least twice each year, otherwise it invades the garden with a mass of long branches five or six metres wide. The plant is propag-ated by means of seed, which should be sown in pots and the seedlings transplanted to the garden when sufficiently large. *Aberia Caffra* is another plant which forms a most effective barrier to trespassers. In addition to it being a good defensive hedge plant, it is ornamental in appearance and does not require much clipping. When it attains its full height, it forms a useful protection not only against thieves but also against the wind.

As in the case of the Caesalpinia, the plant is propagated by means of seed. Unfortunately *Aberia Caffra* is of comparatively recent introduction to Egypt, and consequently young plants are not available in large numbers. The common Sunt (*Acacia arabica*) forms a moderately good defensive hedge, but is less recommendable than the two first-mentioned plants.

Description of Varieties.

Citrus is a genus of shrubs or trees belonging to the Natural Order *Rutaceae*. Apart from the numerous kinds of citrus trees which we cultivate, the order *Rutaceae* is not largely represented in our gardens. We may, however, mention the fruit-trees *Casimroa edulis* and *Aegle Marmelos*, together with the common ornamental shrub *Murraya exotica* as examples of plants which belong to the same family as *Citrus*. For the benefit of school students, we have given the names of the species of *Citrus* to which the various fruits belong. We must, however, warn those who may interest themselves in the botanical classification of citrus trees, that it is a subject upon which botanists differ. The student must, therefore, be prepared to find that authors adopt different systems of classification.

Citrus aurantium, L., var. *bigaradia.*

Sour, Bitter, or Seville Orange (Ar. *Naring*).

In the "Dictionary of Economic Products of India," Watt states that the Bitter orange is believed by most authors to be originally a native of the outer Himalaya, from Garhwal and Sikkim to the Khasia Hills; and it is probable that its area extends also to Cochin-China. Regarding its passage from India to Egypt, we quote the following account from "Plants cultivated in Egypt" by the late Mr. D. S. Fish :—

"*Naring* is the common Oriental name, as well as the Arabic one, for the Sour of Seville orange. The name apparently comes from the Tamul word *Natrun*, given it on account of its fragrance. From India, the tree is supposed to have reached Persia, where it may have got the name *Narinj* ("like a pomegranate"), on account of its ruddy fruits.

"The word *Narang* (pronounced *Naring* in Egypt) passing through the medium of the Arabs when settled in Spain (since 711 A.D.) became in mediæval Latin *Arancium*, *Arantium*, and *Arangium*, these again being changed into *Aurantium* on account of the colour of the fruit. From *Aurantium* the transition into the French *Orange* and later on into Orange was easy.

"A citrus fruit said to have been found at Thebes is, according to Loret, exhibited in the Berlin Museum under the name of *Citrus Aurantium*, var. *fructu amaro*, but the existence of this doubtful specimen hardly warrants the suggestion that the *Naring* was known to the ancient Egyptians. Probably it was first established as an Egyptian garden fruit only nine hundred years ago. Makrizi quotes Massoudi, a celebrated Arab writer who lived in the first half of the tenth century, as saying that the *Naring* and a Round citron (possibly a sweet orange) were brought from India after the year 912 A.D. They were first grown in Oman. Thence they were transplanted to Basra in Irak, to Syria and to Egypt, where they became very common, but where (according to Massoudi) they lost a good deal of the sweet and penetrating odour and beauty that they had in India. It should be added that to-day the oranges of the Mediterranean region are usually superior to those produced in India."

Common Seville Orange (Ar. *Naring*).

The Seville orange tree is less spreading in manner of growth than the trees of any kind of sweet orange. It is further distinguished (1) by the petioles of the leaves being distinctly winged, especially in young plants, and (2) by the strong and characteristic odour of the

leaves when bruised. The Seville orange is not cultivated on a large scale in Egypt. The best orange candied peel and marmalade are those which are made of the bitter orange. Orange flower water is also made, but up to the present the tree has not been exploited commercially as it deserves to be. The tree exhibits a certain amount of variation, and to cultivate them successfully for the production of fruit or flowers, it is necessary to use grafted plants.

The chief use of the tree in this country is that of a stock upon which to grow other kinds of citrus trees. The quantity of seed obtained from 1,000 fruits is about 4½ kilos. One boy can extract this quantity of seed from the fruit in about sixty-three hours. When grown for fruit or flowers, the trees should be planted 3·5 metres apart, in squares. Alternate trees may be removed if they grow very luxuriantly and require more space later.

Sweet Seville Orange (Ar. *Naring heloua*).

The Sweet Seville orange, Bitter Sweet orange, or *Naring heloua*, resembles the ordinary Seville orange in all respects, except in the fact that the fruit is not acid. The pulp is pale yellow and juicy. The taste is sweet, with a bitter after-taste. It is not a popular fruit, either among the Egyptians or Europeans. The tree is grafted on young plants of the Bitter orange proper. Regarding the history of this orange, Mr. Fish states that it was doubtlessly grown in Egypt for many years previous to the introduction of the fine flavoured orange which was brought into Europe by the Portuguese from China after the discovery of the Cape route. The *Naring helw* may consequently be safely spoken of as the oldest sweet orange of the Mediterranean region, and it may perhaps have been derived in Europe or in the Levant from the Sour or Seville orange.

Rough Seville Orange.

Another sub-variety of Bitter orange is occasionally met with in Egypt. This is characterized by irregular excrescences on the skin. It is usually known as *Naring wardi*. It is, however, very rare, and of no economic value.

Citrus Aurantium, L., var. *lusitanica*, *sinensis*, or *dulcis*.

Sweet Orange, Portugal Orange (Ar. *Bortuqan*).

The Sweet orange most probably originated in China or Cochin China. The following extract from Mr. D. Fish's work already mentioned gives a résumé of what is known regarding the introduction of the Sweet orange to this country :—

" The Portugal variety is not the oldest sweet-fruited orange in

Egypt, although it is by far the commonest in the country to-day. The oranges that were brought from China *via* the Cape into Lisbon by the Portuguese in the first half of the 16th century were better than any hitherto known in the Mediterranean region, and hence the name of Portugal became attached to them. This stock has given rise to most of the varieties now cultivated in Europe.

"The date when the Portugal orange reached Egypt is not known, but it would probably not be long after it had fruited near Lisbon. The first writer to mention its existence in Egypt is apparently Forskal, who visited Egypt in 1761–1762. He calls it *Narindj bortughal*. When Delile visited the country at the end of the 18th century, the name had become the present day one of *Bortuqan*. It is interesting to note that the Niçois peasants still call the orange "Portogali."

"The 'Round Citron' of Abulfeda (about 930 A.D.) and the 'Red French Lemon' of Ebn Ayyas may have been, as Silvestre de Sacy suggests, a Sweet orange. Abdel Latif also speaks of a sort of lemon called Mokhattam (sealed), which was of a deeper and brighter red than the Sour orange (*Naring*). The fruits were perfectly round and slightly flattened at both ends as if pressed by sealing, hence the name. The only orange in Egypt, however, which has a deeper red skin than the Seville orange is the Blood orange."

Common Egyptian Orange (Ar. *Bortuqan beledi*).

The tree of the Common Sweet, Egyptian or *beledi* orange is of moderately strong growth and upright habit. For the greater part it is very prolific, but trees frequently occur which bear little or no fruit. Sufficient care is not exercised to avoid the propagation and multiplication of these trees. Generally speaking, the quality of the fruit is good. There is, however, a good deal of variation and the quality can be greatly improved by attention to the selection of trees from which we take propagation material. Propagation is effected by budding on stocks of the Bitter orange. The average weight of the fruit is about 108 grammes. Each fruit contains about nine rather large seeds. In India the Common orange of Egypt is known as the Suez orange. It does not differ greatly from varieties of the same class which are cultivated in other parts of the Mediterranean region. Varieties which are distinguished by desirable qualities have been selected from this stock in various parts of the world. Such is the Teneriffe Paper Rind which has a thin skin, Valencia Late and Cetennial, which ripen their fruit later in the winter than the Egyptian orange. There is also an ever-bearing race which produces flowers and fruits throughout the year. For various reasons it is doubtful whether the ever-bearing oranges will be of special

value in Egypt, but they have not been fully tried throughout the country.

Soliman Pasha Orange (Ar. *Bortuqan suleymani*).

A variety of the common Egyptian orange appeared in the garden of Yusef Pasha Soliman. This is of most excellent taste, even when unripe, and deserves to be widely propagated. The leaves are long and narrow, which fact gives the tree a very distinctive appearance.

Round Jaffa Orange (Ar. *Yafawi medawar*).

A variety which was brought by the Ministry of Agriculture from Australia, under the name of "Jaffa," promises to be of value here. It bears heavy crops of fruit in bunches of five to six at the ends of the branches. The fruit is large and of good quality. It of course bears no resemblance to the true Jaffa or Shamouti orange, but the name of Jaffa has been retained, and it is now known as "Jaffa-round." The original trees appear to be grafted on the Rough Lemon stock. They have grown strongly, but young plants on the Bitter orange have not made good progress; others are growing well on Decumana, Rough Lemon, and Lime stocks.

Flat Orange (Ar. *Bortuqan mebattab*).

An orange which was first brought to notice by Osman Bey Abu Shanab and is very much depressed at both ends. It is known as the flat or the Shenabi orange. It is of Greek origin. It is a prolific bearer, and will probably become popular on account of its long-keeping quality.

Sugar Orange (Ar. *Bortuqan succari* or *tunisi*).

The Sugar orange differs from the common sweet orange in the fact that the former is totally lacking in acidity. The fruit is also characterized by the large number of seeds up to twenty or even more and by the yellowish colour of the skin. The Sugar orange is a favourite with the Egyptians, although Europeans consider it insipid. Owing to its extreme sweetness, it can be gathered early in the season when prices are high. It is therefore a profitable variety to plant at present. It cannot, however, have any future as an export fruit to Europe.

Washington Navel Orange (Ar. *Bortuqan abu surra*).

The Washington Navel orange or *Bortuqan abu surra* was first brought to Egypt by the Alexandria Horticultural Society in 1903.

It was not, however, propagated and distributed until 1911, when the Department of Agriculture imported several improved forms, such as Golden Nugget, Navelencia, and Thompson's Improved, from the United States. The Navel orange may be readily distinguished by the umbilical formation at the apex of the fruit. This characteristic is, however, not peculiar to the Washington Navel. It sometimes occurs even in the common Egyptian orange. The Washington Navel is a fruit of excellent quality, and larger than the Egyptian orange. The skin is smooth, moderately thin, and easily peeled. The flesh is juicy, sweet, and of good flavour. Seeds are either entirely absent or very few in number. This variety is one of the earliest to ripen, and consequently always brings good prices. The tree grows more rapidly and to a larger size than the *beledi* oranges. It also differs from the latter in that its branches are more spreading and less erect. The Washington Navel is not a prolific bearer in this country. It has always been grafted on the Bitter orange, and there is reason to think that we shall have better results by using the Rough Lemon stock which is now being tried.

Khalili White Orange (Ar. *Khalili abiad*).

What is known as the Khalili White orange was found in the garden of Mustapha Pasha Khalil. In its somewhat oval shape and thick skin, it appears to be intermediate between the Common orange and the Shamouti. It has, however, no special quality to recommend it to the commercial grower. In leaf and manner of growth, the tree resembles that of the *beledi* orange.

Shamouti Orange.

The Shamouti orange is that which is cultivated so largely at Jaffa and exported to Egypt and England. The tree with its large leaves and somewhat pendant shoots differs greatly in appearance from trees of other varieties, to which it is also inferior in height. The fruit is large and oval. The skin is very thick, which fact makes the packing and transport of the fruit without damage especially easy. The fruits are entirely or almost seedless. They ripen late in the season and may be left on the trees until the month of May if necessary. The Shamouti does not bear very freely in Egypt. The trees are budded on the Bitter orange stock. Whether better results can be attained by the use of another stock is not yet known. In Palestine the trees are budded on the Bitter orange and on the Sweet lemon stock, the last-named being preferred on light land. It is a curious fact that the Jaffa orange tree was almost unknown in Egypt until the Ministry of Agriculture began its propagation in 1911, although Jaffa

is so near and the fruit comes to us in such large quantities every year.

Khalili Red Orange (Ar. *Khalili ahmar*).

The Khalili Red, like the Khalili White, was found in the garden of Khalil Pasha Fawzy. It is somewhat oval in shape. The skin is thicker than that of the Egyptian orange, and both the skin and flesh exhibit some of the colour of the Blood orange. Although the pulp is sweet and of good flavour, the variety is of no special value to the cultivator. It is, however, interesting as an intermediate from between the Shamouti and the Blood orange. Vegetatively, the tree does not differ from the true Blood orange.

Blood Orange (Ar. *Bortuqan ahmar* or *abu dam*).

The Blood orange is said to have been brought to Egypt from Malta in 1830 by Prince Ibrahim Pasha. The tree does not grow so high nor does it yield so freely as the common Sweet orange. The fruits are small and are further characterized by the crimson colour of the skin and flesh. The markings of the flesh vary from a uniform dark crimson to mere traces of colour. Fruit of uniform colour throughout brings the best prices, hence the necessity of selecting the trees for propagation. The skin of the Blood orange is for the greater part very adherent and difficult to peel. The number of seeds is very variable, some trees bearing fruit which is almost seedless. The Blood orange is not very sweet, but it possesses a distinct and pleasant flavour. The colour of the fruit is not fully developped until late in the season, therefore the crop should not be gathered until the months of February and March, or even later. The tradition that the colour is produced by grafting the Sweet orange on the pomegranate is, of course, without foundation.

Variegated-leaved Orange.

A variety of sweet orange with variegated leaves is occasionally met with, but this is not of great commercial value.

Myrtle-leaved Oranges.

Myrtle-leaved forms of both the sweet and bitter oranges are said to exist in the country, but I have not seen them.

A myrtle-leaved form of the mandarine is fairly common, but this is of ornamental value only.

Citrus Aurantium, L., var. *Japonica-Kumquat.*

The Kumquat is a shrub or small tree which bears a small orange-like fruit. The skin is thin and sweet, and the fruit may be eaten raw without removing it. The pulp, however, is somewhat bitter, so that it is more usual to use the fruit in a preserved state. The fruits are first pierced with a fork and soaked in lime water, after which they are boiled in syrup. The Kumquat is regarded as a great delicacy by the Chinese. The leaves of the bush resemble those of mandarine, *i.e.* they are narrower than the leaves of an orange. There are two varieties in Egypt : one has oblong fruits and is known as the *Nagami* Kumquat ; the other has round fruits and is known as the *Maruni* Kumquat.

The Kumquat is still rare in Egypt. It does not grow well upon the Bitter orange stock, but young plants recently budded upon the Lime stock are making good progress.

Citrus Aurantium, L., var. *Bergamia.*

Bergamot Orange (Ar. *Limoon gargamoon*).

The trees now existing in the Ministry's garden were progagated from a specimen received from Italy in 1911, but the variety is said to have been originally brought to the country by Prince Ibrahim Pasha in 1830. The plant grows well when grafted upon the Bitter orange stock. The leaves resemble those of a lemon-tree more than the leaves of the Sweet orange. The fruit is broadly pear-shaped, rounded at the apex, tapering rapidly to the base. Length about ninety millimetres, diameter about seventy-eight millimetres. Pedicel set in a depression. Skin pale yellow, thin, smooth. Pulp almost white, with a musky flavour. The Bergamot is cultivated chiefly in the province of Calabria, Southern Italy. The rind is there used for the production of bergamot oil, which is employed in the manufacture of perfumes. In the same district, the pulp of the bergamot is used in the manufacture of citrate of lime. A delicate perfumed oil is also obtainable from the flowers. The Bergamot is still rare in Egypt.

Citrus Nobilis, Lour.

Mandarine (Ar. *Yusef Effendi*).

The mandarine most probably originated in Cochin China. It was probably brought to Europe about 1805, and to Egypt twenty-five years later. As compared with oranges, the various kinds of mandarines do not differ greatly one from the other in the characters

of the fruit. They, however, exhibit marked differences in the manner of growth of the trees and to a less extent in the leaf. The mandarine may be easily recognized by its loose skin and characteristic odour of its fruit. The mandarine is a fruit which deserves special attention in Egypt. It is of easy cultivation and bears good crops here. Sold locally it brings higher profits than the orange, which has to compete with imported produce from Jaffa and elsewhere. No mandarine fruits are imported to Egypt from abroad. The alternation of good crops and bad crops is more marked in the mandarine than in the orange, but notwithstanding this fact, the average yearly returns are highest in the case of the mandarine. As an export fruit also, there is every reason to think that the mandarine will be a fruitful source of profit. A variety of mandarine which produces rather dark skinned small fruits is known as Tangerine. This, however, is rare in Egypt, and it does not appear to have any special value.

Common Mandarine (Ar. *Yusef Effendi beledi*).

The Common mandarine is a small tree with an almost globular head 3–5 metres in diameter and the same measure in height. The tree bears slender shoots and broadly lanceolate leaves 6–7 centimetres long and 2 centimetres wide at their broadest part. Petioles slightly margined but not winged. The fruit varies between 60 and 75 millimetres in diameter. It is also for the greater part sweet, juicy, and of good flavour. The skin is bright orange in colour, not adherent to the flesh, thin, and depressed at the apex of the fruit. The number of seeds is usually about twenty. The Common mandarine is a delicious table fruit, attractive in appearance and easy to peel. As in the case of other fruits in Egypt, the best mandarines are mixed with a great many which are mediocre in quality. Improvement can therefore be effected by means of selection on the part of the propagator. The plants grow well on stocks of Bitter orange. They are planted at a distance of three and a half metres apart and afterwards "thinned" by the removal of alternate trees. The mandarine bears freely, moderately good grafted trees producing an average of not less than 500 fruits per year weighing fifty-six kilos. It is popularly supposed that the mandarine owes its Egyptian name of *Yusef Effendi* to its introduction from Malta by a person of that name in 1830. As pointed out by the late Mr. D. S. Fish, there is reason to doubt the truth of this story, as Delile at a much earlier date used the name for another kind of citrus fruit.

Clementine Mandarine.

The Clementine mandarine tree resembles that of the Common mandarine in size, form, and appearance, but the leaves are larger,

attaining a length of 10 centimetres or more, and a breadth of 4 centimetres. In outward appearance the fruit resembles a small orange more than a mandarine. The skin is deep orange in colour, thin, smooth, usually protruding at the base, adhering somewhat to the flesh and forming a ridge on one side of the fruit. The average diameter of the fruit is 57 millimetres and the number of the seeds is usually twenty-two or twenty-three. These are more elongated than the seeds of the Common mandarine. The fruit is very sweet, but its peculiar value lies in the fact that it ripens somewhat earlier than the Common mandarine. It is, however, more subject to the attacks of the fruit fly. The Clementine mandarine originated in the garden of the orphanage of Misserghin in Algeria, and was named in honour of Brother Clement, the Director of the gardens of that institution. Dr. Trabut, who investigated the origin of the variety, is of opinion that it is an accidental hybrid between the mandarine and the Bitter orange. The original plant appeared in a batch of mandarine seedlings. The variety was brought to Egypt by means of budwood in 1911, and from this have been propagated all the trees distributed in Egypt. The tree grows well when budded upon stocks of Bitter orange.

Matania Mandarine (Ar. *Suntara*).

The Matania mandarine is represented in the gardens of the Ministry by a seedling tree received from India and by trees received from two sources in Egypt. These trees have proved to be identical in variety. The specimen from India was received under the name of "Suntara," but as this is applied to a group of varieties, the name of "Matania" has been given to this particular one. This name was first given to the variety on account of the fact that one of the gardens in which it was found belongs to Mr. A. Bircher, El Saff, Matania. The leaves of the Matania mandarine differ from those of the Common mandarine in being broader in comparison to their length. A leaf which is 60–70 millimetres long, is 30–35 millimetres broad. The most striking feature of this and other varieties of the Suntara group of mandarines, however, is the straight upright growth of the branches and the consequent narrow form of the tree. Some of the older trees of the Matania variety at Gîza are 4–5 metres high and not more than than $2\frac{1}{2}$ metres in diameter. An average-sized fruit is 70 millimetres in diameter. The skin is loose, smooth, thin, light orange in colour, and protruding somewhat at the base of the fruit. The seeds are smaller than those of the Common mandarine and not very numerous, about fifteen in each fruit. The trees grow well and bear freely on the Bitter orange stock. The fruit ripens somewhat later than the Emperor and Satsuma, but before the King variety.

This mandarine has the valuable property of being more resistant to drought and to variation of soil humidity that the Common or Beledi mandarine.

King Mandarine (Ar. *Yusef Effendi melooki*).

The King or Melooki mandarine was brought to Egypt from America in 1911. The tree which was then imported is growing at Gîza. It has been cut very severely for the supply of bud-wood, so that the tree has not been able to assume its natural form. Notwithstanding this fact, however, it is evident that the manner of growth is the same as that which characterizes all varieties of the Santara group of mandarines. The form of the tree is narrow and upright. The leaves are somewhat larger than those of the Matania variety. The fruit of the King mandarine is large, attaining a diameter of 90 millimetres, but the skin is thick, rough, and slightly adherent to the flesh. The seeds are large and number as many as twenty-eight in one fruit. Very few people like the flavour of this fruit, and it is not probable that it will become popular in Egypt. Swingle expresses the opinion that " the original *C. nobilis* of Loureiro was undoubtedly something very like the King orange. . . . This variety was found by Loureiro growing in Cochin China in the latter half of the 18th century, and was introduced in America by Mrs. S. R. Magee of Riverside, California, in 1880, from Saigon, Cochin China, which introduction became known as the King orange (Walter T. Swingle in " The Standard Cyclopedia of Horticulture," 1914, vol. II, page 784). The King grows well and fruits freely on the Bitter orange stock. The fruit ripens later in the season than any other mandarine.

Emperor Mandarine.

In foliage, manner of growth, and type of fruit, the Emperor, or as the gardeners prefer to call it, the Imperatore mandarine does not differ greatly from the Matania mandarine. The variety was imported from Australia in 1911. The average diameter of the fruit is about 60 millimetres. The skin is pale orange in colour, smooth, thin and loose, but without any protuberance at the base. The seeds are small and number fifteen to sixteen each fruit. The Emperor does not grow well when budded upon the Bitter orange stock. Young plants are, however, doing well on the Rough lemon and lime. The fruit ripens before that of the Matania variety.

Satsuma Mandarine (Ar. *Yusef Effendi Satsuma*).

In foliage and habit of growth, the Satsuma differs widely both from the Common and from the Suntara type of mandarine. The

leaves resemble more closely those of an orange or a lemon than do mandarine leaves, and the tree is characterized by its spreading somewhat pendant shoots which are totally different to the erect growths of the Suntara type of tree. The characters of the flowers and fruit are, however, those of a mandarine. As in the case of the King, the Satsuma tree which was first imported has been too heavily cut for propagation purposes, to allow it to attain its natural dimensions. In America, it is described as a small tree, " more like a shrub or bush than the ordinary orange." The fruit is of medium size, the average diameter being about 75 millimetres. The skin is bright orange in colour, moderately thick, somewhat rough on the surface, adhering loosely to the flesh below. The flavour is good. The fruits usually contain few seeds, and many of the latter are characterized by the prominence of the wing at the base. Young trees which have been budded on the Bitter orange stock are not growing very well, but those on the Sweet lemon and lime are making satisfactory progress.

Red Mandarine (Ar. *Yusef Effendi ahmar*).

The Red mandarine is a small tree. The leaves are those of an Egyptian lime, although to the casual observer they present the appearance of mandarine leaves. The fruit is globular and about four centimetres in diameter. The skin is bright orange in colour, thin, peeling without difficulty, and possessing a faint smell of mandarine. The flesh is also bright orange in colour, juicy, not very acid, seeds aborted. The taste is agreeable, although rather musky. The tree is highly prolific, and when in fruit is very ornamental.

Yellow Mandarine (Ar. *Yusef Effendi asfar*).

What is known as the Yellow mandarine does not possess all the characters of the fruits described above under the name of mandarine. The tree resembles that of an Egyptian mandarine which is grown from seed. It is deciduous, and has numerous thorns of different lengths. The leaves are those of a mandarine. The fruit is small, being about four centimetres in diameter. The skin is thin and peels easily, as in the case of other mandarines. It is, however, lemon in colour. The sections of the fruit are easily separated, the pulp is yellow and tastes like an acid lemon. The seeds resemble those of a mandarine. They have greenish white cotyledons. The tree is highly ornamental when in fruit, but otherwise it has no commercial value.

Citrus Medica.

Sir George Watt states that "the name Medica given to this species is derived from the fact that in one of the first unmistakable references to it, the fruit is spoken of as the apple of Media. The acid forms at least have well-marked Sanskrit names, and there would appear to be no doubt that the cultivation of the plant spread from India to Mesopotamia and Media, from whence it became known to Europe. The presumption is therefore that it is a native of India, and in confirmation of this opinion, one or two forms of a wild plant, supposed to be the source of the citron and the lime, are common on the outer Himalaya. . . .

"It seems probable that the home of the former may be found to be the mountain tracts of Eastern Bengal, more particularly of the Khasia and Gares hills, while the latter is of a more northern character, extending along the foot of the Himalaya to the Punjab. The sweet lime (*C. Limetta*) appears to be the southern manifestation of the species, and the writer would be disposed to look for the lemon in the Far East, if not in China, even although the Chinese names for it do not occur in the ancient writings. As a cultivated plant it may have spread from China to India before it had attracted much attention in China itself. Although not wild, the plant is more frequent in Assam than in Bengal, and it is possible that it may have entered India across the Chino-Assam frontier.

"*Citrus Medica* includes the citron, and the sweet and acid forms of the lemon and lime. The different varieties are frequently confused by old writers and it is often impossible to determine exactly what fruit they are speaking of. The citron itself is supposed to be the first of its genus to be known in the West."

From the extract quoted above, it will be seen that the name Medica does not refer to the medical properties of the plants, but to Media, where they are supposed to have been established early in the Christian era.

Egyptian Lime (Ar. *Limoon beledi*, *rachidi*, or *benzaheir*).

The first mention of the lime under that name appears to be made by Sir Thomas Herbert, who speaks of finding "Oranges, Lemons, and Limes" in the island of Mohelia (in the Comore group of Mozambique) during a voyage begun in 1626.

Sir George Watt states that "the Arabic word 'limoon' through the Persian, is the Hindi "lime," "limbu," probably adopted by the Sanskrit people."

Regarding the date of introduction of the lime to Egypt, the late Mr. S. D. Fish writes as follows in "Plants cultivated in Egypt":—

"Abdel Latif (1200 A.D.) became acquainted with several kinds

of Citrus in Egypt, and these he discusses under the general heading of 'acid fruits.' But the lime cannot be definitely identified with any of the fruits mentioned by Abdel Latif. No account of its introduction into Egypt exists, but it is probably safe to assume that it passed to Egypt from India, *via* Arabia. The Custard Apple, the Banana and other plants not unlikely reached Egypt by the same route. Thevenot is apparently the first writer to allude to the lime in Egypt. In his account of the Mataria garden, at one time famed for its plants of Gilead Balm (*Balsamodendron apobalsamum*), he alludes to 'des petits limons,' and these could hardly have been anything else but limes.

"Thevenot visited Mataria in 1657. No doubt the lime was commonly found in Egyptian gardens at that time."

The Egyptian lime is a low, spreading, thorny tree, attaining a diameter of seven metres when propagated by means of seed without being grafted. The leaves vary in length between 55 and 80 millimetres and in width between 30 and 40 millimetres. The short petiole is slightly but distinctly winged. The fruit is globular or somewhat oval, about 40 millimetres in diameter; average weight 34 grammes, skin usually thin and pale yellow when ripe; number of seeds usually about six, pulp pale, juicy, and acid.

In this country the tree is almost entirely propagated by means of seeds. Propagation by means of layers is practised to a very small extent. Such a method cannot of course be carried out on a large scale. The practice of grafting the tree is unfortunately unknown to cultivators, although grafted trees have the advantages of being less thorny and of coming into bearing more quickly than those which are grown directly from seed. Moreover, grafting is the only means of multiplying trees of selected varieties. The Egyptian lime is said to be too small for sale in European markets, but even if this should prove to be true in future, the importance of the fruit for local consumption is sufficiently great to justify all attempts to improve it. Individual trees bearing fruit of exceptional merit are frequently found in plantations of seedling trees. The value of a grove composed entirely of such high-class trees would of course be very much higher than that of a grove which is made up only of ordinary unselected trees.

The employment of grafted plants is therefore to be strongly recommended. Three-year-old trees which are budded on the Bitter orange stocks have borne freely this year at Gîza. Until more information is available regarding the question of stocks for this and other trees in Egypt, the safest course is to bud the lime on its own roots, *i.e.* to bud selected varieties on young plants of lime which have been raised from seed, which may be sown in March or in September. The lime tree is more resistant to drought than other

citrus trees, for which reason it may prove to be of value as a stock for oranges, etc., on dry sandy land. It also grows well on alluvial land, and there are very few gardens in Egypt where the lime is not grown. Its cultivation on a commercial scale is, however, most largely carried on in the Faiyûm, and at Bashteel in Gîza Province. Formerly it was grown for market largely at Rosetta, hence the name of *limoon rashidi*. The industry has, however, almost entirely disappeared in that district. The name of *benzaheir* is usually supposed to refer to the ever-bearing character of the tree, but it is more probable that the word is derived from the Persian (*ben* = against, *zehir* = poison), and refers to the medicinal properties of the fruit. Throughout the greater part of Egypt, no special form of cultivation is applied to the lime, but in the Faiyûm and at Bashteel its ever-bearing character is greatly accentuated and developed by means of the systems of irrigation followed.

At Bashteel, where the land is moderately heavy, no water is given between the first week of December and the last week of January. In the latter month the dead twigs and branches are removed from the tree and the land is manured with farmyard manure. The quantity of manure varies between six and twelve baskets (*zambîls*) per tree, the maximum quantity being given to trees which are not growing well.

Kufri manure is sometimes mixed with the farmyard manure, but this is not necessary. The manure is spread over the whole surface of the land, which is then lightly hoed and heavily watered, *i.e.* at the end of January. The land is again hoed in February, but no more water is given until the first week of May, unless the trees show signs of suffering. In the latter month and early in June, three waterings are given at intervals of fifteen days, after which the trees are kept dry for a period of thirty days, in order to encourage the production of young fruits at that season and thus increase the yield of saleable fruit in winter when the prices are high. In the last half of July and in August, the trees are irrigated more frequently—at intervals of twelve days—than at any other season. The main crop of the year is then maturing and a plentiful supply of moisture is required to swell the fruit to its maximum size. A heavy watering is given at the beginning of September, after which the trees are irrigated once each month until the beginning of December, when they receive the last watering of the year. The most important crop is the *Nili*, which is gathered between the beginning of September and the end of November. At this season, the fruit is mostly sold in a ripe state ; but in spring and summer, it is for the greater part sold green.

In the Faiyûm, limes are frequently cultivated together with prickly pear (*Opuntia*), the rows of lime-trees alternating with those

of prickly pear. This, however, offers no advantage as compared with that of planting lime-trees alone. In the province mentioned, two systems of irrigation are followed. Where water is plentiful, the trees receive nine waterings per year, *i.e.* twice each month in August, September, October, and November, and once in March. This is known as the *fâter*. The other system is known as the *sâim* or "fasting," and where this is followed, the trees receive four waterings per year: once each month in August, September, October, and November.

The practice of irrigating lime trees continuously throughout the year, as is done in the majority of gardens, does not lead to the best results. On very sandy land the systems of irrigation outlined above cannot be followed, but otherwise one of them should be adopted and modified if necessary to meet the circumstances of each case.

Seedling trees should not be planted less than five metres apart in squares. If the soil is good, it is necessary to remove every alternate tree afterwards, so as to leave those which remain in quincunx at a distance of about seven metres apart. In the case of grafted trees, they may be planted at the outset in squares at a distance of 3·5 metres apart. The production of adult trees is 2,000–3,000 fruits per year. At the present time the cultivation of the lime tree is highly profitable, the gross returns frequently amounting to L.E. 100 or more per feddân per year. The amount of seed produced by 10,000 limes is about three kilogrammes. One boy is able to extract this seed by hand in 224 hours.

Farid Eff. Munib writes as follows on the uses of limes in Egypt: "Limes have many uses in the sick room, the kitchen, and the house. The juice from a lemon in half a glass of water before breakfast will correct the most torpid liver and prevent bilious troubles. It will cure sore throat when used as a gargle. In fever, the juice of lime is cooling and of great value for moistening the lips and cleaning the tongue. Two or three drops of lime juice in a cup of hot office will cure headache and prevents vomiting. An outward application of lime juice will allay irritation caused by insect bites.

"Tough meat is made less tough by adding a spoonful of lime juice to the water in which it is boiled. Slices of lime are used to garnish and flavour fish.

"Lime juice with olive oil instead of vinegar is preferred by many for salad dressings. Lemon ice is one of the cheapest, most healthful and refreshing desserts for summer. Lemonade (lemon squash) is a national drink. After the juice has been extracted, the rind dipped in salt will clean tarnished brass. Salt and lemon juice will remove rust, ink, or fruit stains from white goods. Lemon juice removes stains of all kinds from the hands and prevents roughness and chapping.

" A cloth soaked in lemon juice and bound around a cut stops severe bleeding until medical aid can be secured.

" Lime juice in water is used for cleaning the eyes instead of boric acid solution. Lime juice is used as a drink against the effect of poison. Lemon fruits are roasted and used with opium to cure toothache.

" Limes are pickled and used to a large extent by all the natives, especially the poor class.

" Lime juice is served with many kinds of food, especially with germinated (*nabit*) and digested (*madammiss*) beans. Apart from the use of limes for beverages and culinary purposes, large quantities are employed in other countries for the production of citric acid and distilled lime oil.

West Indian Lime (Ar. *Limoon americani*).

In the West Indian Islands, especially in the Island of Dominica, the lime is cultivated on a large scale for the production of lime juice. Several varieties which are characterized by the lack of spines or by the small number of seeds in the fruit have been selected from the plantations, but that which is most generally known as the spineless lime is one which was found in Dominica in 1891. It is reported that when this variety is propagated by means of seed, about 75 per cent of the young plants possess the characters of the parent.

Seed was obtained by this Ministry in 1911, and trees are now growing at Giza. The growth of the trees is more upright and less spreading than in the case of the typical lime tree. The branches are thornless, and the leaves are more rounded at the apex than those of the Common lime. Most of the leaves are also mucronate, and the short petiole is wingless. The fruit of the trees growing at Gîza is small, the average weight being about 25 grammes only.

Trees which are cultivated on more sandy soil may, of course, be expected to yield larger fruit.

Tests made by Farid Eff. Munib show that one kilogramme of fruits of West Indian limes yields about 0·104 gallon of juice, and that the same quantity of Egyptian limes yields about 0·108 gallon.

Analyses made by Mr. Frank Hughes show that the acidity in ounces per gallon of juice (as citric acid) is 15½ in the case of the West Indian lime from Gîza. The juice from Egyptian limes bought in the market gave a result of 13½ ozs. per gallon. The average weight of these fruits was 32 grammes each, but other Beledi fruits obtained from Wardan weighed 43 grammes each, and the acidity of the juice was 13½ ozs. per gallon. At Wardan the trees are cultivated on drift-sand with the aid on manure. It will probably be found that

the acidity of the juice is greatly influenced by the system of irrigation followed in the cultivation of the trees.

It should be pointed out that the West Indian lime seldom contains more than one to two seeds. The trees at Gîza produce very poor crops. The main crop ripens in October. The trees appear to be less resistant to fungous diseases than those of the Common lime. Several have suffered at Gîza from Wither-tip and gumming of the main branches. The thornless character of the tree is advantageous, as it facilitates gathering, but it must be remembered that other varieties become practically thornless when propagated by means of budding.

Abaza Lime.

A distinct variety of lime was found in the garden of Soliman Bey Abaza at Zagazig by Ahmed Bakri, the chief gardener of the Ministry. This closely resembles the West Indian Spineless lime in its erect manner of growth, in the shape of its leaves and in the absence of thorns. The fruit is somewhat small, very thin-skinned, and contains several small brown seeds with green cotyledons. The parent tree was in very bad health when found, being crowded among other trees. Nothing is known of its origin. One young tree which was propagated in the garden at Gîza has borne a few fruits this year. It is not probable that the variety will prove of great commercial value.

Riadi Lime.

In this variety, the leaves are larger than those of the typical lime, and in this respect it resembles an Italian lemon more than the lime. The fruit is seedless. The parent tree was also found by Ahmed Bakry in the garden of Riad Bey Rabiya at Kutamia, Sharqîya Province. As in the case of the Abaza lime, the tree was crowded among other trees and was almost dead when found.

Young trees now exist at Gîza, and the variety gives promise of being a valuable addition to the lemons cultivated in Egypt.

Lime Sultan Hussein.

This variety is supposed to have been introduced from one of the Greek Islands by H.H. the late Sultan Hussein, for which reason we have given it the name which it now bears. It has hitherto been grafted upon stocks of the Bitter orange. When propagated in this manner, it forms a low compact tree or bush of slow growth. A seven-year-old tree at Gîza has not yet reached a height of two metres. It is not yet known how the tree will grow upon other kinds of stocks.

The twigs are slender and erect. The leaves are 60–80 millimetres long and 30–40 millimetres wide. Petioles are almost wingless. Petals slightly red on the lower surface. Anthers almost white. Style short. The tree is ever-bearing, but not very prolific. The fruit is oval, about 58 millimetres long and 48 millimetres in diameter, slightly mammilate at the apex, and with a slight apophysis at the base, thin-skinned, juicy, acid, and seedless.

This lime is of excellent quality, but its commercial value cannot be estimated until more study has been given to the propagation and cultivation of the tree.

PERSIAN LIME (Ar. *Limoon agami*).

This is another seedless lime. It resembles the Sultan Hussein lime in fruit, and also in the fact that plants which are grafted upon the Bitter orange grow slowly and do not exceed the dimensions of a medium-sized shrub. In manner of growth, however, it differs greatly from the Husseini lime. The shoots are stout and not continuous in growth. New shoots arise angularly behind the arrested growing point of the old shoot, so that the branches point irregularly in all directions. The leaves differ from those of the Husseini lime in being thick, stiff, and somewhat larger in size. The petals of the flowers are pure white or occasionally showing traces of red. The style is short, and the pollen sacs empty. When grafted on stocks of the Common lime, the tree grows strongly and bears good crops of fruit. It produces its fruit throughout the year. The skin is smooth, light yellow in colour and thin. The pulp is juicy, acid, and seedless. The trees are ever-bearing, and the variety promises to be of great value in Egypt, more especially as it produces a large proportion of fruit during summer.

This and the three following varieties belong to what is known as the Limetta group of limes or lemons. Plant 3·5 metres apart.

OASIS LIME (Ar. *Limoon waha*).

Fruits of a seedless lime have been received from Dakhla Oasis. These are almost globular in shape, with a pronounced nipple at the apex. The size is that of a rather large orange. The skin is smooth and very thin. The flesh is seedless, very juicy, acid, and with the flavour of an Italian lemon. I have not seen the leaves and flowers, but the appearance of the fruit leads me to think that it belongs to the same group as the Persian lime and Sweet lime of Egypt. It would probably be a valuable market variety and an attempt will be made in March to introduce it to cultivation in the Nile Valley.

Sweet Lime of Egypt (Ar. *Limoon heloua beledi*).

The Sweet Egyptian lime forms a moderately large round-headed tree 3–5 metres high and 4–6 metres in diameter. In its crooked habit of growth and in appearance of the leaves, it resembles the Persian lime, but the leaves are less dense on the shoots and the branches are less dense than in the case of that variety. The branches are furnished with thorns as much as 7 centimetres long. They are sometimes found even on grafted trees. The flowers of the Sweet Egyptian lime show no trace of red colour. The style is of normal length, and the stamens are fertile.

The fruit is globular in shape, about 65 millimetres in diameter; skin thin, smooth, pale yellow, with a very slight trace of a mamelon at the apex. Pulp white, juicy, sweet, not acid. Seeds about eight. The tree is a free bearer. It is cultivated fairly commonly in Egypt, and a certain quantity of fruit is also imported. The late Mr. D. S. Fish states that it is "probably an old inhabitant of Egyptian gardens." The fruit is very popular with the natives of the country, but Europeans usually regard it as being insipid in taste. Owing to its sweetness, it can be used early in the season, consequently it is found in the market from November and onwards throughout the winter. In this country the tree is mainly propagated by means of cuttings. We find that it grows badly when budded upon Bitter orange stocks, but upon stocks of the Egyptian lime, its growth is rapid and healthy. In Palestine, the Sweet lemon serves as a stock for the propagation of the Jaffa orange, and is preferred to the Bitter orange stock by some cultivators, especially on land which is light and sandy. Its utility in this respect is under investigation in this country. The production of good adult trees is between 500 and 1,000 fruits, and early in winter they realize prices superior to those of beledi oranges.

Sweet Musk Lemon (Ar. *Limoon heloua mistikawi*).

The Musk lemon is borne on a tree of rather small dimensions. The branches are spreading and the young shoots are somewhat slender and willow-like. The ovate leaves vary considerably in size, being 7–11 centimetres long. The upper surface is dark shining green in colour. Flowers pure white. Fruit globular 45–50 millimetres in diameter, mamelon conspicuous, arising from an apical depression. Skin thin, smooth, with slight varicose swellings, especially towards the apex. Flesh very light yellow, juicy, sweet with a strong musky flavour. Seeds about eight. This fruit is preferred to the Sweet lemon by many people. The trees now growing in the garden were received from Italy. Young plants have been found to grow well on stocks of Bitter orange. Plant 3·5 metres apart. We also have a

Musk acid lemon, but its taste is disagreeable. It is therefore not worth growing.

Sweet Lemon of India (Ar. *Limoon heloua kommetra*).

This tree is characterized by an upright more or less compact habit of growth. The shoots are moderately stout. The shoots are densely furnished with leaves which vary greatly in size and shape. The short wingless petioles are yellowish in colour and most usually bend towards the stem, the blade of the leaf spreading outwards.

Some of the flowers show traces of red on the sepals and petals. Fruit oval, 7 centimetres long, 5 centimetres in diameter, strongly mamilate at the apex. Skin pitted and thick. Flesh yellow and sweet. Seeds six to eight.

It is a mid-season fruit, commencing to ripen towards the end of December. The plant grows well and bears freely when budded on the Bitter orange, but it grows more strongly on stocks of the Common lime. Owing to its compact habit, the trees can be grown at a distance apart 3·5 metres. This fruit is inferior in quality and commercial value to the Sweet lemon of Egypt and also to the Sweet lemon of Italy.

This and the following varieties of lemons are often grouped under the botanical name "Limonum." They are distinct from the preceding varieties and also from the citrons.

Sweet Lemon of Italy (Ar. *Limoon Adalia heloua*).

This variety produces a round-headed tree with spreading branches. The leaves are those of a typical acid Italian lemon, except that they are green when young. The flowers usually have traces of red on the sepals and petals. The fruit is oval, about 70 millimetres long and 50 millimetres in diameter, with a pronounced mamelon at the apex. The skin is much thinner than in the case of the Sweet lemon of India. Flesh yellow, juicy and sweet. Seeds usually about nine. Like the preceding variety, this fruit does not commence to ripen until December, although it is a week or ten days earlier than that variety. It has a better flavour than the Sweet lime of Egypt and is much superior to the Sweet lemon of India in having a moderately thin skin and very little fibre. The tree is very prolific and grows well on the Bitter orange stock. Plant 5 metres apart.

Italian Acid Lemon (Ar. *Limoon Adalia hamid*).

This is one of the most vigorous of all citrus trees. In rapidity of growth and size, it exceeds the orange and almost all other varieties

of lemon trees which are grafted upon the Bitter orange stock. It sends out long spreading shoots. The flowers and young leaves are reddish in colour. The familiar oval fruit is 8–9 centimetres long, mammilate at the apex. Number of seeds variable, sometimes not exceeding one or two, other fruits containing five or six well developed seeds and the same number of aborted seeds. The most important lemon-producing centres of the world are situated in Sicily and the south of Italy. The best fruit is exported to America, Europe, etc., and inferior fruit is used in the manufacture of citrate of lime, lemon oil, and lemon peel. About one-fourth or one-third of the total crop is used in this way. Like other limes and lemons, the Italian lemon naturally produces small quantities of out-of-season fruits. In Sicily this ever-bearing tendency is developed by withholding water for about sixty days in June and July, and afterwards stimulating the trees to new growth by the application of manure, especially sulphate of ammonia. This treatment leads to the production of a crop of flowers in August and September, and of fruit in the following summer, at a season when lemons are scarce and dear. Italian lemons are not grown on a large scale in any part of Egypt, and no special system of irrigation is followed.

Trees have been subjected experimentally to the Sicilian system of irrigation, and it is found that it retards the ripening of the crop greatly. If lemons can be put on the market in the month of June, the crop will be highly profitable. This can be done only by retarding the maturation of the crop and by means of proper storage. During the year 1922, we kept our lemons until May 13, with an average loss of 9 per cent of decayed fruit. It is hoped that past trials will enable us to improve our methods of packing and get better results in future. When planted in the field, the trees are arranged 5 metres apart in squares. After a lapse of eight or ten years, alternate trees are removed so as to leave those which remain 7 metres apart.

An adult tree produces an average crop of 500 lemons per year, weighing 75 kilos. One hundred fruits grown in Egypt were found to yield about 76 gallons of juice when pressed by hand and strained. Tested by Mr. Frank Hughes, the acidity in ounces per gallon of juice was found to be eleven and a half. Sicilian lemons are stated to yield a juice containing 11–13 ozs. acidity to the gallon. The manufacture of 300 kilos. of calcium citrate is said to require an average of 100,000 lemons, the peel of which yields 37 kilos. of essence. In Sicily, lemon-peel for export is packed in barrels filled with salt-water. Some kinds are composed of peel from which the oil has been removed, and in other kinds the oil has not been taken from the peel. Lemons which are required for domestic use should be picked as soon as they have attained their full size, and just before they change colour. They should then be wrapped separately in tissue paper, packed in boxes,

and placed in a cool room. If a few weeks the lemons become yellow in colour, thin-skinned, and full of juice, whereas those which are allowed to ripen on the tree are thick-skinned, less juicy, and often bitter in taste.

As stated above, the Italian lemon tree is a vigorous grower. It frequently sends up long robber-shoots from the base through the middle of the tree. Needless to say, these should be cut out as soon as they appear, except where one is required to fill a vacant place in the head of the tree. The shoots from the fruiting branches must also be shortened each year, otherwise the tree assumes a straggling irregular form with long branches which are too weak to support the weight of a crop. In forming the framework of the tree, it is well to keep the head moderately open in the centre.

Italian Round Lemon (Ar. *Limoon Adalia medawar*).

The tree of this variety resembles that of the ordinary Italian lemon in leaf, size, and habit of growth. The fruit varies in shape, but is usually more globular than in the case of the common Adalia. It is also very frequently marked with a line or section of raised orange coloured skin on one side. The seeds are variable in shape and size. This variety is very probably a hybrid between an orange and a lemon. The flavour is not good.

Rough Lemon of Florida (Ar. *Limoon maharfish*).

This variety is represented in the garden at Gîza by two trees which were received from Florida in 1913. The trees have attained a height of 4–5 metres. They are upright in growth and not widely spreading. The leaves are those of an Italian lemon. The fruit is round or somewhat pear-shaped, flattened at the apex, with a very pronounced apophysis at the base. Skin light orange-coloured, moderately thick, very rough and corrugated. Seeds about fifteen. The interest attaching to this lemon lies in the fact that it is used extensively as a stock for other citrus trees in Florida, Australia, etc.

It is said to be moderately immune to the attacks of collar-rot and it will probably be found very useful in this country as a stock upon which to grow oranges, etc., which do not grow well upon the Bitter orange. As a market fruit, the Rough lemon has no value.

Red Italian Lemon (Ar. *Limoon Adalia ahmar*).

The variegated lemon is a comparatively small tree. The leaves vary greatly in size, but otherwise they do not differ from those of the Italian lemon, except in the irregular white variegation of the

margins. The fruit is oval, 60–75 millimetres long and 50–55 millimetres in diameter. The skin is moderately thick, smooth, with slight varicose swellings near the apex. The pulp is orange-pink in colour, juicy, and acid. Seeds about five in number. The skin of this lemon is useful in making puddings and cakes, imparting a peculiarly pleasant flavour. Lemonade which is made of the fruit is also peculiarly agreeable in taste. The tree grows well upon stock of the Bitter orange. Plant 3·5 metres apart.

Rough Lemon of Egypt (Ar. *Naffash*).

This is a moderate-sized spreading tree. The fruit is oval in shape, flattened at the apex, about 85 millimetres long and 70 millimetres in diameter. The skin is light yellow in colour, 11–12 millimetres in thickness, with irregular excrescences on the surface, especially towards the apex of the fruit. Pulp pale yellow, acid. Seeds numerous.

This tree has been tried as a stock for other citrus trees, but they invariably "gummed" very badly and died. The "Naffash" has therefore been given up as a stock. The fruit is excellent for jam-making Plant 3·5 metres apart.

Lemon "Ponderosa" (Ar. *Kabbad*).

This is a small tree with large thick leaves and thick stout shoots. The fruit is slightly pear-shaped, about 125 millimetres long and 110 millimetres in diameter. The skin is about 11 millimetres in thickness, smooth and occasionally furrowed longitudinally. The pulp is whitish, juicy, and moderately acid. Seeds numerous. There is less demand in Egypt for lemons of this type than for the smaller-fruited varieties. Excellent lemonade is made of the juice of the "Ponderosa," and the skin is useful for preserving with sugar, for flavouring salads, etc. This variety was imported from the United States. Plant 3·5 metres apart.

Egyptian Citron (Ar. *Trong beledi*).

The Citron is produced on a small tree or large shrub of straggling and irregular growth. The leaves are almost always more oblong and rounded at the apex than are those of lemon trees. The fruit of this variety is widest towards the apex, where it attains a diameter of 87 millimetres. Its length is 144 millimetres. A furrow runs down two sides of the fruit and divides it at the apex into two short fingers. Skin smooth, forming the entire fruit, which is quite pulpless. Seeds six.

The chief use of the Egyptian citron tree is that of a stock for the propagation of orange and mandarine trees. The citron stocks are easily raised by means of cuttings, and the young plants are more easily budded than Bitter orange or other kinds of stocks. During the first few years of their life, young trees on the citron stock grow vigorously and bear good fruit. The roots of the citron are, however, not sufficiently strong to support an adult tree, and the latter usually falls into ill-health before it reaches an age of twenty years. To avoid this, cultivators resort to the practice of planting the trees deeply in order to bury the point of union between the stock and the scion, and thus encourage the production of roots from the scion itself: mandarine or orange, as the case may be.

In any case, the trees are usually attacked by " mal-di-goma " at the age of 12–14 years, and, before the 20 years are past, they have either disappeared entirely or have arrived at a state of decrepitude when the garden is quite profitless. It is rare to find a good garden more than forty years old if the trees are growing on the trong. Such trees do not support heavy pruning for purposes of renovation, differing in this, as in other respects, from trees which are growing on stocks of Bitter orange. For the production of cheap orange or mandarine trees for use as temporary plants between other trees, the use of the citron stock is permissible, but otherwise it is not to be recommended.

Sultan Citron (Ar. *Trong sultani*).

The fruit of this variety is more elongated in comparison to its diameter than in the case of the Egyptian citron. The length varies between 225 and 285 millimetres and the diameter from 90 to 99 millimetres. Furrows running irregularly down both sides of the fruit divide the apex into two or three more or less distinct short fingers. The colour of the skin is pale lemon. The fruit is pulpless and usually seedless.

This and the previous variety are often spoken of as " fingered " citrons, and the fruits are frequently used as charms by the fellaheen.

Faiyûm Citron (Ar. *Trong faiyûmi*).

The Faiyûm citron is an oblong or oval-shaped fruit, about 156 millimetres long and 120 millimetres in diameter. It is slightly ridged and furrowed on the sides. The rind is about 20 millimetres thick, and encloses a moderately acid whitish-coloured pulp with 25–30 seeds. The Faiyûm citron belongs to the class known as commercial citrons. They are largely grown for export in some of the Mediterranean islands and especially in Corsica.

The fruit is exported in barrels of salt water and after being immersed in this for several months the peel is washed and placed in a hot syrup. It remains in the syrup for three weeks. It is afterwards cooked and cooled alternately in syrup until it is sufficiently crystallized, when it is ready for use.

The citron is probably a native of Northern India. It has been cultivated in Egypt probably since the 4th century, and perhaps from an earlier date. What has been supposed to be the representation of a citron appears on a temple of the 15th century B.C. at Karnak. It is, however, doutful that the drawing is intended to represent a citron.

The commercial citron is now almost unknown in this country. The tree is never very healthy. Until recently it has always been propagated by means of cuttings and grown upon its own roots. Young plants which have been budded upon lime and Decumana stocks are growing strongly and give promise of developing into healthy trees.

Gîza Citron (Ar. *Trong gizâwi*).

The Gîza citron is similar to the Faiyûm variety, except in that it is pointed at the apex, and the skin is rougher than that of the Faiyûm citron.

Alexandrian Citron (Ar. *Trong skandarani*).

The fruit of this variety is almost globular in shape, and the skin is smooth.

Minya Citron.

The Minya citron is a narrow elongated fruit with rough skin. It is of less value than the Gîza or Faiyûm varieties.

Miniature Citron (Ar. *Trong sokhair*).

The tree of this variety is more bushy than in the case of other varieties of citrons, the twigs are more slender, and the leaves more like those of a lemon than are the leaves of other citrons, but notwithstanding this, close inspection at once shows that they are the leaves of a citron and not of a lemon. The fruits are pear-shaped and do not exceed 70 millimetres in length. The rind is 5 7 millimetres thick and encloses a yellowish, acid, seedless pulp. The tree is useless and is included here merely to show that the extent of variation in citrons is quite as great as in other forms of fruits belonging to *Citrus Medica*.

Citrus Decumana, Linn.

Grapefruit, Pumelo, Shaddock, *Limoon hindi.*

The Pumelo is a native of the islands of the Malay Archipelago.

The trees vary in size according to the variety: some growing 4–5 metres high, others not exceeding a height of 2–3 metres. The shoots are pubescent and the leaves are usually characterized by a broad wing on the petiole. The fruit varies from the size of a large orange to that of a small more or less globular water melon. The flesh also varies in colour. Several varieties are found in the gardens of Egypt, but some of these are evidently of hybrid origin. None are of commercial importance, except the grape-fruit. The grape-fruits are small-fruited fine-skinned varieties of shaddocks which have been selected in the United States. That known as Duncan has been found to be particularly good in Egypt and has been largely distributed by the Ministry of Agriculture. It is increasing in popularity and there is reason to think that the establishment of plantations of this tree will soon become a commercial proposition. Among the fellaheen gardeners the grape-fruit is known as Limoon Hindi Americani. The trees grow well upon the bitter orange stock. They may be planted at the outset at a distance of 3·5 metres apart.

The various kinds of trees belonging to *Citrus decumana* should be studied as stocks upon which to grow oranges and mandarines.

Other Citrus Fruits.

The foregoing pages do not include all the varieties of citrus fruits which are found in Egypt. Many which are not mentioned here may be seen in the gardens of the Ministry. They are, however, of botanical interest only. Different species of *Citrus* hybridize freely one with the other, and in the United States this facility of hibridization has been made use of for the production of many interesting crosses. Foremost among these are the citranges which are hybrids between *Citrus trifoliata* and the Common orange. Some of these are growing well at Gîza and serve to show the fundamental trifoliate nature of all citrus leaves. The Tangelos are crosses between the mandarines and grape-fruits, and limequats are crosses between limes and kumquats. Tengelos and limequats have not yet been brought to Egypt. *Citrus trifoliata* has been tried several times at Gîza, but without success.

FIG. 1. — شكل ١

Young orange tree grafted on the Bitter orange "stock" at the proper height above the ground, dug with a ball of earth and properly packed for transport.

شجرة برتقال صغيرة مطعومة على النارنج على الارتفاع المطلوب فوق سطح الأرض وقد نقلت بصلاية من الطين وحزمت جيدا استعدادا لنقلها .

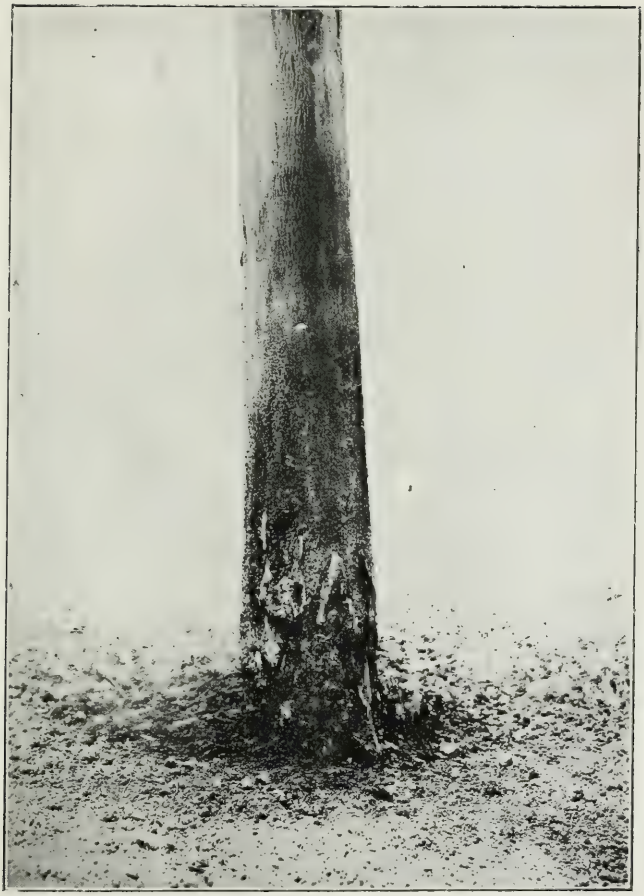


FIG. 2. — شكل ٢

Stem of Sweet orange tree grown from seed. The effect of the "mal-di-goma" or collar-rot disease on the bark is seen at the base of the stem. The plantation in which this photograph was taken died in three years from the time that the attack first appeared.

ساق شجرة برتقال مزروع من البذرة يرى فى أسفله تأثير المال دى جوما أو التعفن الحلقى . وقد ماتت أشجار المزرعة التى أخذت منها هذه الصورة بعد ظهور المرض لأول مرة بثلاث سنين .

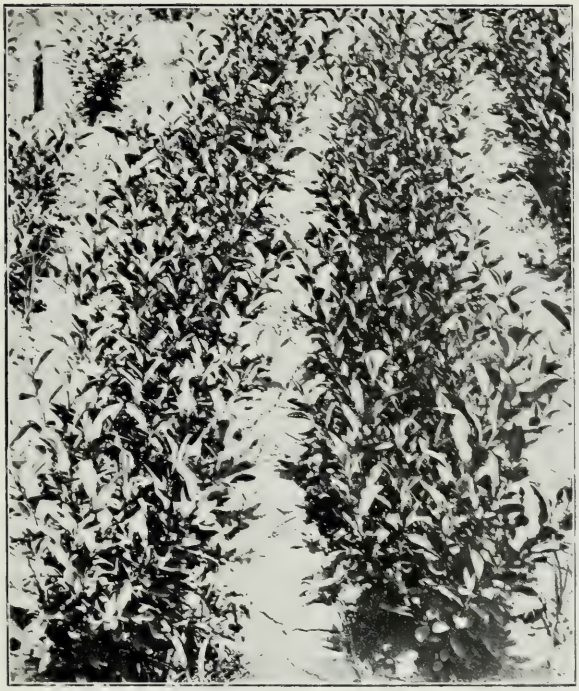


FIG. 3. — شكل ٣

Seedlings of limes one year old. Seed sown in September.

نباتات ليمون بلدى بذرية (شتلة) عمرها سنة واحدة وقد زرعت البذرة فى شهر سبتمبر

FIG. 4. — شكل ٤

Sketch of hoe of a suitable shape for digging trees.

رسم فأس صالحة لتقليع الشجر بها

FIG. 5. — شكل ٥

Photograph of ox and plough working in nursery.

صورة محراث يجره ثور واحد يشتغل بالمشتل

Fig. 6. — شكل ٦

One ox drawing a light cultivator between the nursery rows of Bitter orange "stocks"

صورة ثور يجر عزاقة بين صفوف النارنج فى المشتل .

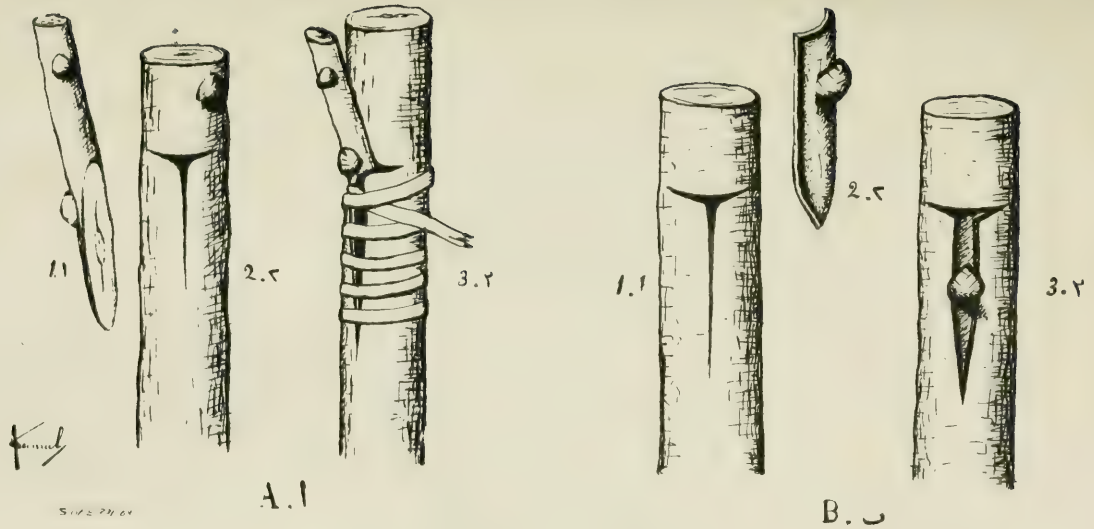


Fig. 7 شكل ٧

(A) Diagram showing method of side-grafting

(1) Scion prepared for insertion on stock.

(2) Stock prepared to receive scion.

(3) Scion inserted on stock.

(B) Diagram showing shield-budding commonly employed in the propagation of citrus trees.

(1) Stock prepared to receive bud.

(2) Bud ready for insertion on stock.

(3) Bud inserted ready for binding with raffia fibre

(أ) رسم يبين طريقة التطعيم الجانبي

(١) الطعم محضر لتطعيمه على الاصل .

(٢) الأصل جاهز لتطعيمه .

(٣) الطعم بعد التطعيم .

(ب) رسم يبين الطعم الغمدى المستعمل عادة فى تطعيم الاشجار الحمضية

(١) الأصل جاهز لتطعيمه .

(٢) الزر جاهز لتطعيمه على الأصل .

(٣) الزر بعد تطعيمه جاهز لربطه برباط الرافيا .

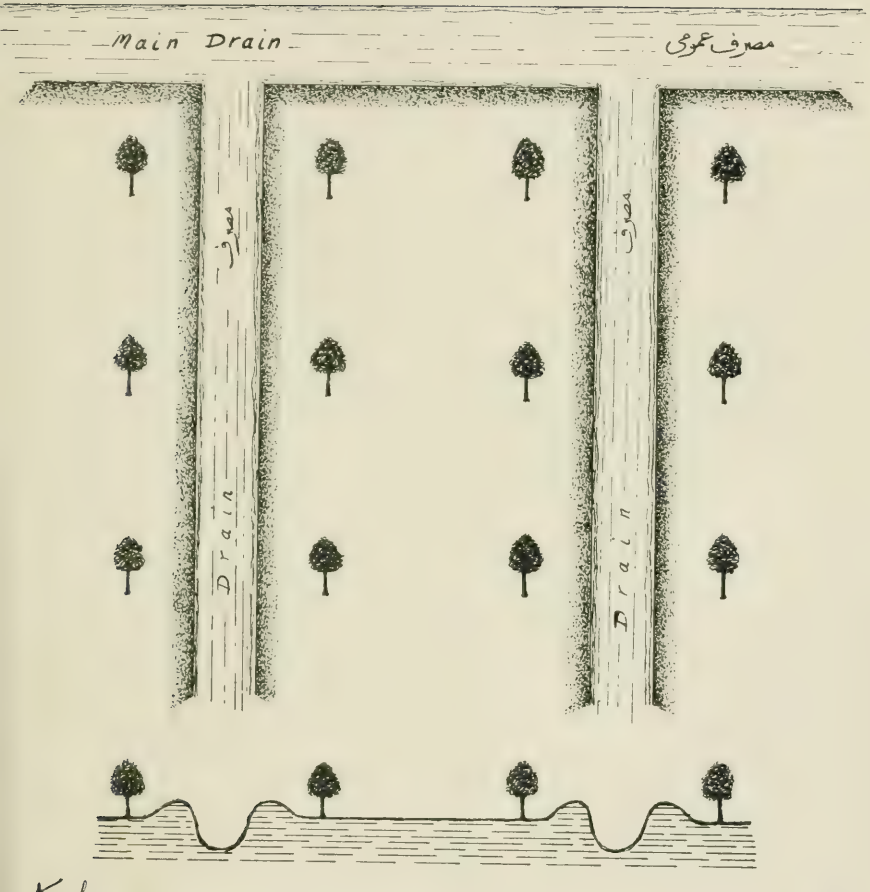
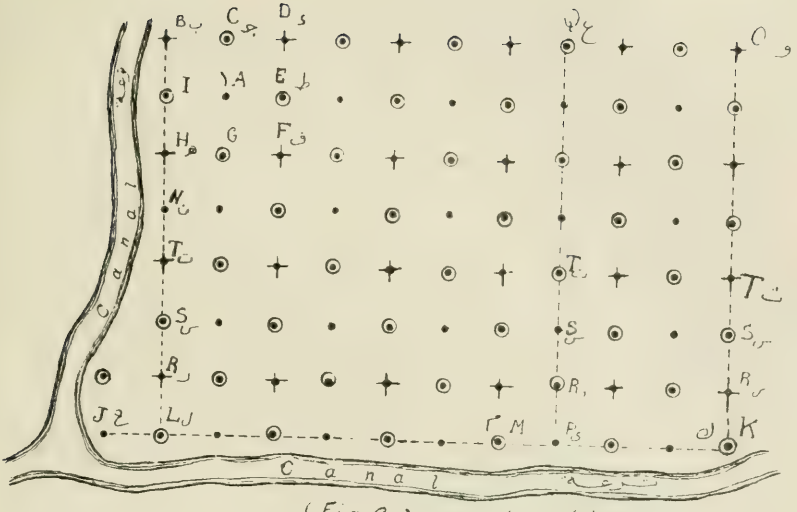


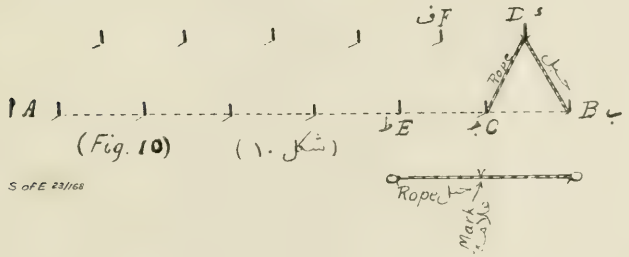
Fig. 8 شكل ٨

Diagram showing position of drains and trees on land impregnated with salt. Such land should not be planted with trees until the crop of bersim has been grown, and afterwards the drains should be continued until the salt has been altogether removed.

رسم يبين موقع المصارف والأشجار فى أرض مسبخة . ويجب أن لا تزرع مثل هذه الأرض بأشجار قبل أن ينمو بها البرسيم ويجب أن تبقى تلك المصارف حتى تخلو الأرض تماما من الأملاح .



(Fig. 9) (شكل ٩)



(Fig. 10) (شكل ١٠)

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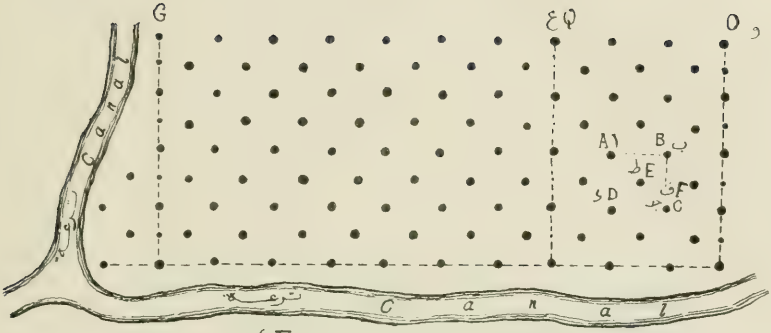
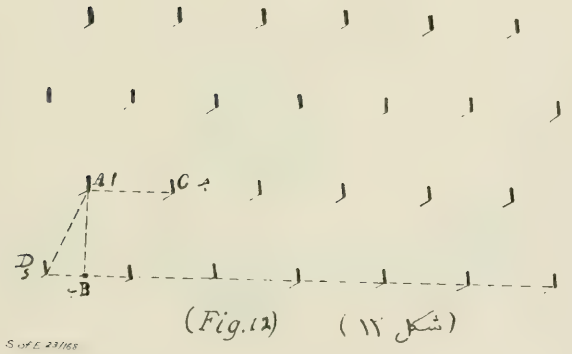
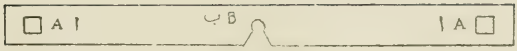
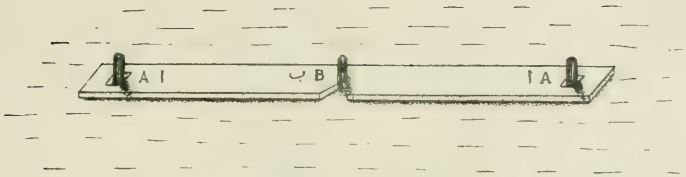


(Fig. 11) (شكل ١١)



(Fig. 12) (شكل ١٢)





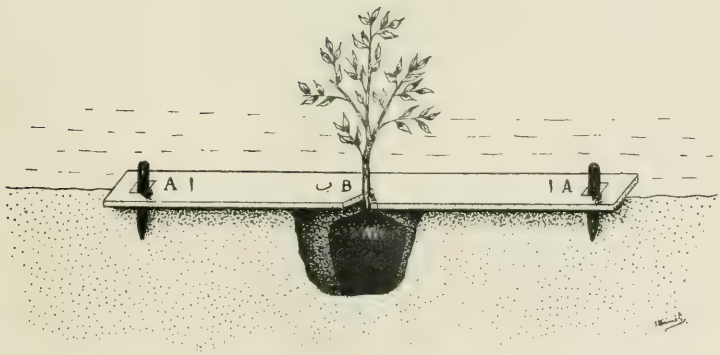


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Fig. 13 شكل ١٣

(1) Planting-board used for placing a tree in its exact position in the field.
(2) The peg (B) marks the place of the tree. The board is first placed on peg (B) and the pegs (A) inserted.
(3) The peg (B) is removed with the board. The hole is then dug, the board is placed on the pegs (A) and the stem of the tree is inserted in the notch at (B) which is the exact place of the first peg.

(١) لوحة الزرع تستعمل لوضع الشجرة فى موضعها من البستان بالضبط .

(٢) الوتد (ب) يعين موقع الشجرة . توضع لوحة الزرع أولا على الوتد (ب) ثم يوضع الوتدان (أ)

(٣) يزال الوتد (ب) وكذا تزال لوحة الزرع ثم تحفر الجورة وتثبت اللوحة على الوتدين (أ) ثم يدخل ساق الشجرة فى الفتحة (ب) التى هى الموضع الحقيقى المضبوط للوتد الأول .

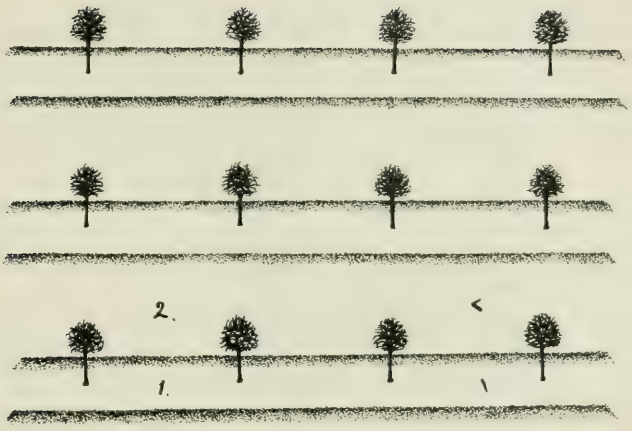

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Fig.14 شكل ١٤

(1) Tree-bed. (١) بواكى الشجر .

(2) Bed for beans. (٢) بواكى لزرع الفاصوليا .

FIG. 15. — شكل ١٥

Lima beans growing in beds between trees. It will be seen that the bed in which the trees are planted is kept quite free of beans and weeds.

الفاصوليا الليما مزروعة فى بواك بين الأشجار. يلاحظ أن بواكى الشجر خالية من الفاصوليا وكذلك من الحشائش.

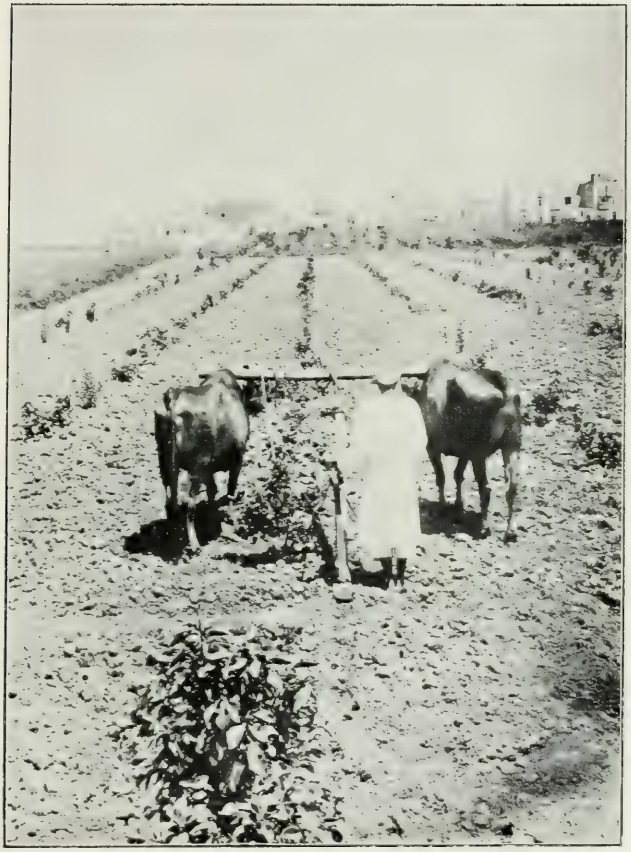


FIG. 16. — شكل ١٦

Photograph of oxen ploughing in young orange orchards. The oxen are yoked widely apart, so that the plough can approach quite close to the trees, one ox on each side of the trees.

صورة تبين الحرث بواسطة ثورين فى حديقة برتقال صغيرة و يلاحظ ان الثورين هنا متباعدان عن بعضهما بحيث يمكن الحرث بالقرب من الأشجار وأن الثورين يحرثان كل منهما على جانب من الأشجار.

Fig. 17. — شكل ١٧

Another view of the oxen shown in Figure 16.

منظر آخر للثورين المبينين فى شكل ١٦

Fig. 18. شكل ١٨

Photograph of cultivator, showing three broad flat sweeps used in breaking the surface of the land between trees in the orchard.

صورة عزاقة تبين ثلاثة أسلحة عريضة تستعمل فى تفكيك التربة السطحية بين الأشجار بالبستان .

Fig. 19 — شكل ١٩

Photograph showing teeth used in work between young tree in the nursery rows.

صورة تبين أسنان العزاقة التى تستعمل فى العزيق بين صفوف المشتل .

FIG. 20. — شكل ٢٠

Photograph showing method of preparing irrigation beds by means of bullocks and ridgers. It should be noted that in this photograph the oxen are yoked more closely together than is the case in Figures 16 and 17.

صورة تبين طريقة عمل المساقى بواسطة الثيران والبتانة ويجب ملاحظة أن الثورين فى هذه الصورة أقرب لبعضهما عما هما فى شكلى ١٦ و ١٧

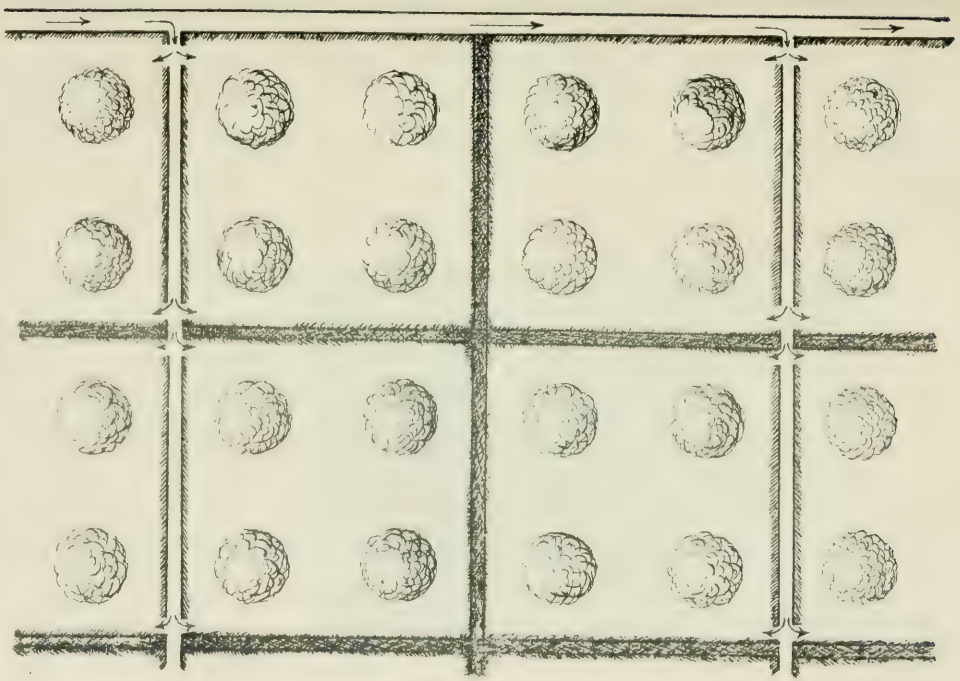


Fig. 21 شكل ٢١

Diagram showing the arrangement of beds and canals in the basin system of irrigating plantations. This system should always be followed where the land is at all saline. If the necessity arises for a *light* watering to be given during the time of flowering or when the fruit is small, temporary water-canals should be made between the trees. It is dangerous to run the water over the whole surface at that time.

رسم يبين ترتيب مواقع الأشجار المساقى فى طريقة الرى بالأحواض . ويجب اتباع هذه الطريقة دائما اذا كانت الأرض ملحية . واذا احتاج الامر لرية خفيفة أثناء التزهير أو عندما تكون الثمار صغيرة تعمل مساق وقتية بين الأشجار لأن اطلاق الماء على جميع أجزاء الأرض فى مثل هذه الظروف ضار جدا .

Fig. 22. – شكل ٢٢

Sweet orange tree growing upon the citron "stock," for comparison with that shown in Figure 23. The latter is growing upon the roots of the Bitter orange. The two trees are of the same age and are growing close together under identical conditions.

صورة شجرة برتقال مطعومة على ترنج لمقارنتها بمثيلتها فى شكل ٢٣ المطعومة أصلا على النارنج وكلتاهما من عمر واحد ومزروعتان تحت ظروف واحدة .

FIG. 23. — شكل ٢٣

Egyptian Sweet orange tree grafted upon the Bitter orange "stock." Note the development of this tree as compared with that shown in Figure 22.

صورة شجرة برتقال مطعومة على النارنج. يلاحظ نموها بالنسبة للشجرة المبينة بشكل ٢٢

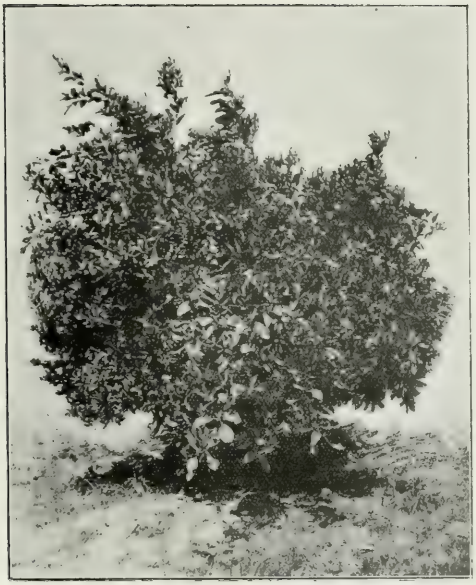


FIG. 24. — شكل ٢٤

Navel orange tree showing the somewhat pendent habit of the branches as compared with the upright branches of the Egyptian Sweet orange tree shown in Figure 23.

صورة شجرة برتقال بسرة لمقارنتها بشجرة البرتقال البلدى المبينة بشكل ٢٣ وكيف أن الأولى فروعها مائلة بينما الثانية فروعها قائمة

Fig. 25. — شكل ٢٥

This picture shows a mandarine tree which is grafted on the citron (*trang*) stock. It is growing close to the tree shown in Figure 26, and the two trees are of the same age Note the difference in size.

تبين هذه الصورة شجرة يوسفى مطعومة على الترنج وهى مزروعة بجوار أخرى (شكل ٢٦) وكلتاهما من عمر واحد. يلاحظ الفرق فى الحجم بين الشجرتين.

FIG. 26 — شكل ٢٦

Egyptian mandarine tree grafted upon the Bitter orange "stock." It is of the same age as the tree shown in Figure 25, which is grafted upon the citron stock.

شجرة يوسفى بلدى مطعومة على نارنج وهى من عمر الشجرة المطعومة على ترنج المبينة بشكل ٢٥

FIG. 27. — شكل ٢٧

Santara mandarine. Note the difference in shape between this tree and the tree of Egyptian mandarine shown in Figure 26.

يوسفى سنتارا . يلاحظ اختلاف شكل هذه الشجرة عن شجرة اليوسفى البلدى المبينة بشكل ٢٦

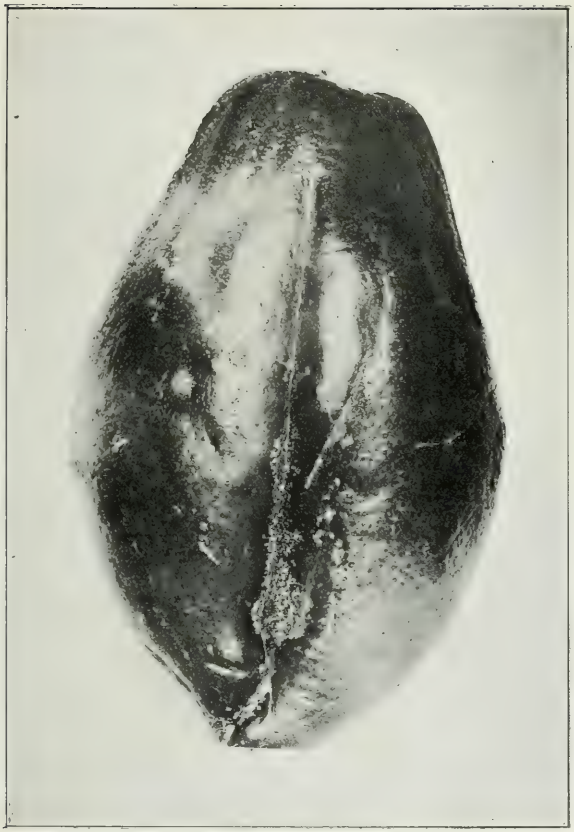


FIG. 28. — شكل ٢٨

Fruit of Egyptian citron. The tree which bears this fruit is largely used as a "stock" upon which to graft other kinds of citrus trees. As a "stock," however, it is greatly inferior to the Bitter orange, lime, etc.

ثمرة الترنج البلدى الذى يستعمل بكثرة كأصل يطعم عليه بقية أنواع الأشجار الحمضية وهو فى ذلك أقل قيمة بكثير من النارنج والليمون البلدى وغيره .

Fig. 29. — شكل ٢٩

Fruit of Egyptian citron cut open to show pulpless centre.

ثمار ترنج بلدى مقطوعة ليرى قلبها بدون لب .

FIG. 30. — شكل ٣٠
Fruit of Sultan citron.
ثمرة ترنج سلطانى.

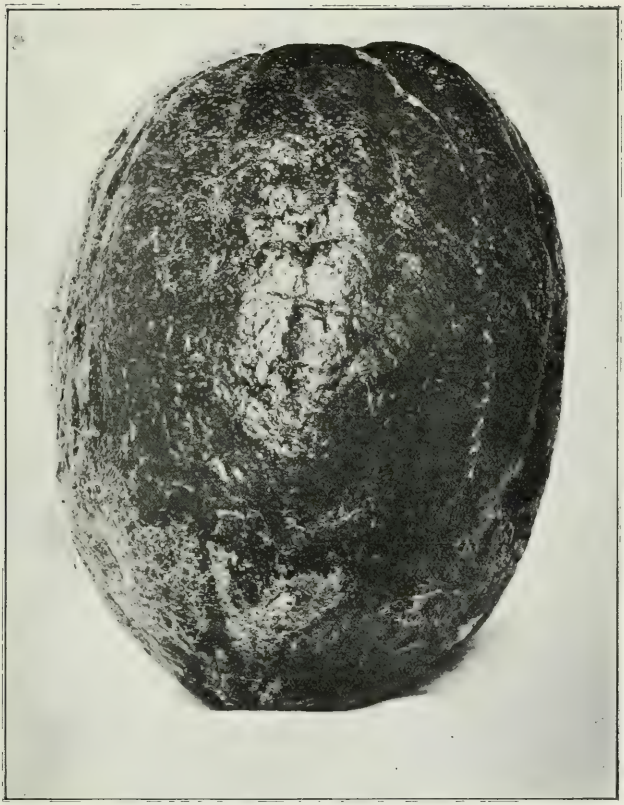
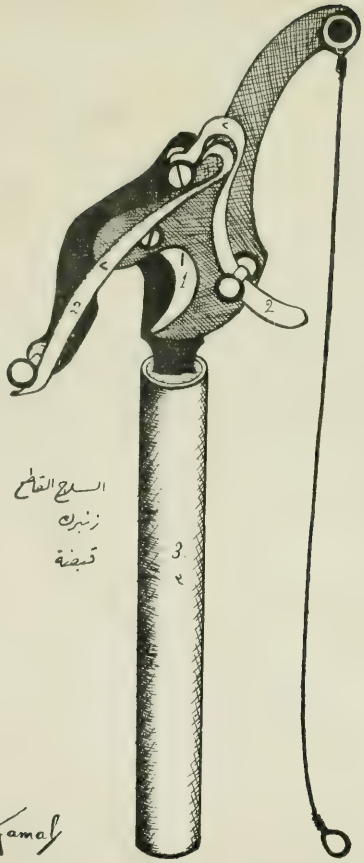


Fig. 31. — شكل ٣١

Faiyúm citron. This is the fruit which is cultivated in some of the Mediterranean islands for the production of citron-peel.

الترنج الفيومى . وهو النوع المزروع ببعض جزائر البحر الأبيض المتوسط لاستخراج قشور الترنج .



1. Blade
2 Spring
3. Shaft

١ السلح القاطع
٢ زنبرك
٣ قبضة

Kamal

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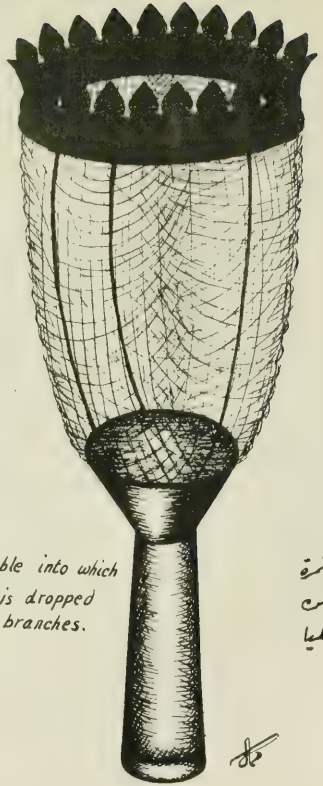

Receptable into which the fruit is dropped from high branches.

وعاء يتلقى الثمرة الساقطة من الأغصان العليا

Fig. 33 شكل ٣٣